Research Note 84-117

AD-A146 709

AN ANALYSIS OF THE CAPABILITY OF ALTERNATIVE DIVISION-86 155mm HOWITZER BATTERY ORGANIZATIONS

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August 1984

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: Research Note 84-117	2. GOVT ACCESSION NO.: AD-A146 709	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): An Analysis of the Capability of Alternative Division-86 155mm Howitzer Battery Organizations		5. TYPE OF REPORT & PERIOD COVERED: Research Note
		6. PERFORMING ORG. REPORT NUMBER: ---
7. AUTHOR(s): Robert E. Robinson, Science Applications, Inc.; C. W. Hannon, Science Applications, Inc.		8. CONTRACT OR GRANT NUMBER(s): MDA903-82-C-0146
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Science Applications, Inc., 1710 Goodridge Drive, McLean, VA 22102		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 2Q263743A790
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Ave., Alexandria, VA 22333		12. REPORT DATE: August 1984
		13. NUMBER OF PAGES: 80
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): US Army Research Institute for the Behavioral and Social Sciences, Fort Sill Field Unit, P.O. Box 33066, Fort Sill, OK 73503		15. SECURITY CLASS. (of this report): UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

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18. SUPPLEMENTARY NOTES

Lloyd M. Crumley, Contracting Officer's Representative

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Combat Capability	Minimum Essential Teams
Field Artillery	Organization
Howitzer Battery	Reconstitution
Interchangeability	Substitutability
AMORE	Simulation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A recent ARI research effort showed that a ten-man howitzer section, trained in accordance with duties as assigned today, could not perform both the war fighting duties and support tasks required to provide fire support and survive over extended periods of intensive, 24-hour per day, combat operations. Based upon field measurements and computer modeling, ~~the ARI effort~~ showed that a better organizational alternative is to split the crew into two teams of five personnel each with the teams alternating between war fighting and support

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) tasks. The present research ~~effort~~ extends the initial ~~ARI~~ analysis by examining and comparing the capability of alternative Division-86 155mm SP howitzer battery organizations following combat degradation. The alternative organizations are structured to provide for support over extended periods of continuous, intensive combat while permitting adequate support man-hours for replenishment and risk reduction tasks. The analysis and comparison are conducted using the Analysis of Military Organizational Effectiveness (AMORE) model which measures the reconstitution capability of a unit over time following enemy attack or other degradations in personnel and/or materiel capability. Based on the analysis of capability following degradation, this analysis shows the desirability of howitzer section organizations comprised of two teams of five members with the Chief of Section either additional to the two teams (preferred) or a member of one of the teams. ~~The~~ analysis also shows the desirability of training to operate in teams of four in the event that ~~combat or other~~ losses decrease personnel strengths to those levels.

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Research Note

AN ANALYSIS OF THE CAPABILITY OF ALTERNATIVE DIVISION-86 155mm HOWITZER BATTERY ORGANIZATIONS

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Department of the Army

September 1982

Army Project Number 2Q263743A790 | Crew Design

AN ANALYSIS OF THE CAPABILITY OF ALTERNATIVE DIVISION-86 155MM HOWITZER BATTERY ORGANIZATIONS

EXECUTIVE SUMMARY

Requirement:

The Fort Sill Field Unit of the US Army Research Institute (ARI) has evaluated the performance of M109A1 howitzer crews. The section as organized and trained today requires ten men for emplacing, eight men for firing, and nine men for march ordering. It was determined that the current definition of crew duties does not permit the howitzer crew to provide the required fire support and, at the same time, perform the risk reduction and replenishment support tasks required for a howitzer section to fight and survive on the modern, high-intensity battlefield where 24 hour per day operations and frequent movements are required. It was concluded, using task time data derived from field measurements and simulations with the ARI Crew Performance Model, that a ten member howitzer section, divided into two teams of five with crew duties redefined appropriately, would be able, at minimal increase in response times, to provide the required fire support and, at the same time, perform the necessary support tasks. The purpose of this research effort, therefore, is to use an alternative methodology to analyze and compare the capability of alternative Division-86 155mm howitzer battery organizations following selected levels of combat degradation to establish the relative advantages of these alternative crew organizations at the battery level.

Procedure:

The present research effort examines the split-crew howitzer section organization and others and compares their capability over time following several levels of combat degradation. The analysis and comparison are conducted using the Analysis of Military Organizational Effectiveness (AMORE) model which measures the capability of a unit with respect to time following enemy attack or degradations in personnel and/or materiel caused by other phenomena. The impact of three other factors--platoon organization, MOS substitutability, and battery size--is also considered.

Findings:

The research effort confirmed previous findings that today's ten member howitzer section, trained in accordance with duties as defined currently, is incapable of providing continuous, 24 hour per day fire support in a rapidly moving, high-intensity combat situation and, at the same time, performing the support and risk reduction tasks required for survival.

Two alternative howitzer section organizations, with crew duties redefined appropriately, a) have a reconstitution capability following degradation at least as good as today's organization, b) are able to provide fire support, at minimal cost in response times, and c) are able to perform required support tasks by alternating the two crews between war fighting and support functions. The alternative organizations, in order of preference, are: a) Chief of Section and two teams of five crewmen (requiring an increase in battery strength from 129 to 137 personnel) and b) two teams of five crewmen with the Chief of Section a member of one of the teams (at Division-86 strength).

At an increased cost in response time, it is also feasible, even salutary in cases of high attrition, to redefine duties and organize the howitzer section into two teams of four crewmen. This solution is only viable, however, if the howitzer section strength is retained at ten, with the members not essential to team operations used to perform support tasks and to substitute for crew casualties or other crew degradations.

In general, unit capability tends to decrease as degradation levels increase. However, the deleterious effects were less for all alternatives relative to the ten-man base case. Finally, none of the three other factors considered--platoon organization, MOS substitutability, and battery size--had a significant impact on unit performance.

Utilization of Findings:

This report confirms the relative inefficiency of the M109 howitzer section as currently organized. The advantages of several alternative battery organizations have been presented. Therefore, crew duties should be developed for a five-member team. Crew training should also be developed at the four-member team level in the event combat casualties or other degradations reduce howitzer section strength to that level.

AN ANALYSIS OF THE CAPABILITY OF ALTERNATIVE DIVISION-86 155mm HOWITZER BATTERY ORGANIZATIONS

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SECTION I

INTRODUCTION

1.1 BACKGROUND

The Fort Sill Field Unit of the US Army Research Institute (ARI) has evaluated the crew performance of the M109A1 howitzer crew of the 155mm howitzer battery during emplacement, firing and march ordering.[1] Their analysis revealed that as fighting duties are currently specified and the ten man crew is currently trained, all ten members of the crew are required for emplacement, eight are required for firing, and nine are necessary for march ordering. (During march ordering, the tenth member of the crew is the gun guide (GG) who usually goes forward with the recon party.)

At the same time, the analysis showed that more than 129 man-hours of crew member time can be required daily for support tasks (as opposed to fighting tasks). Support tasks are of two types. The first is the replenishment type which ensures that the section equipment is maintained properly, the section is supplied adequately and the personal requirements of the crew members are satisfied. The second is the risk reduction type which enhances a howitzer section's ability to survive.

Considering the fighting duties of the section and the fact that, as currently constituted, only two crew members are available during firing to perform support tasks (a maximum of 48 man-hours of labor available per day), it is clear that during the extended periods of high intensity continuous combat which can be expected on the battlefields of the future, it would be impossible to fight the battle, and at the same time perform all of the required support tasks. Performance of the support tasks is required if the howitzer section is to be able to provide continuous effective fire support.

Using their Crew Performance Model and task time data derived from field measurements, ARI simulated the performance of crews of various sizes with crew member duties redefined in accordance with crew size. Crew performance was measured in terms of time required to emplace, fire a one-round mission or march order. Results are summarized in Figures 1-1, 1-2, and 1-3. As a result of the analysis,

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[1] Crumley, Lloyd M., Schwalm, Robert C., and Coke, Jay S., An Evaluation of the Effects of Various Task Assignment Alternatives on M109A1 Howitzer Crew Performance, US Army Research Institute for the Behavioral and Social Sciences, Research Report 1337, July 1982.

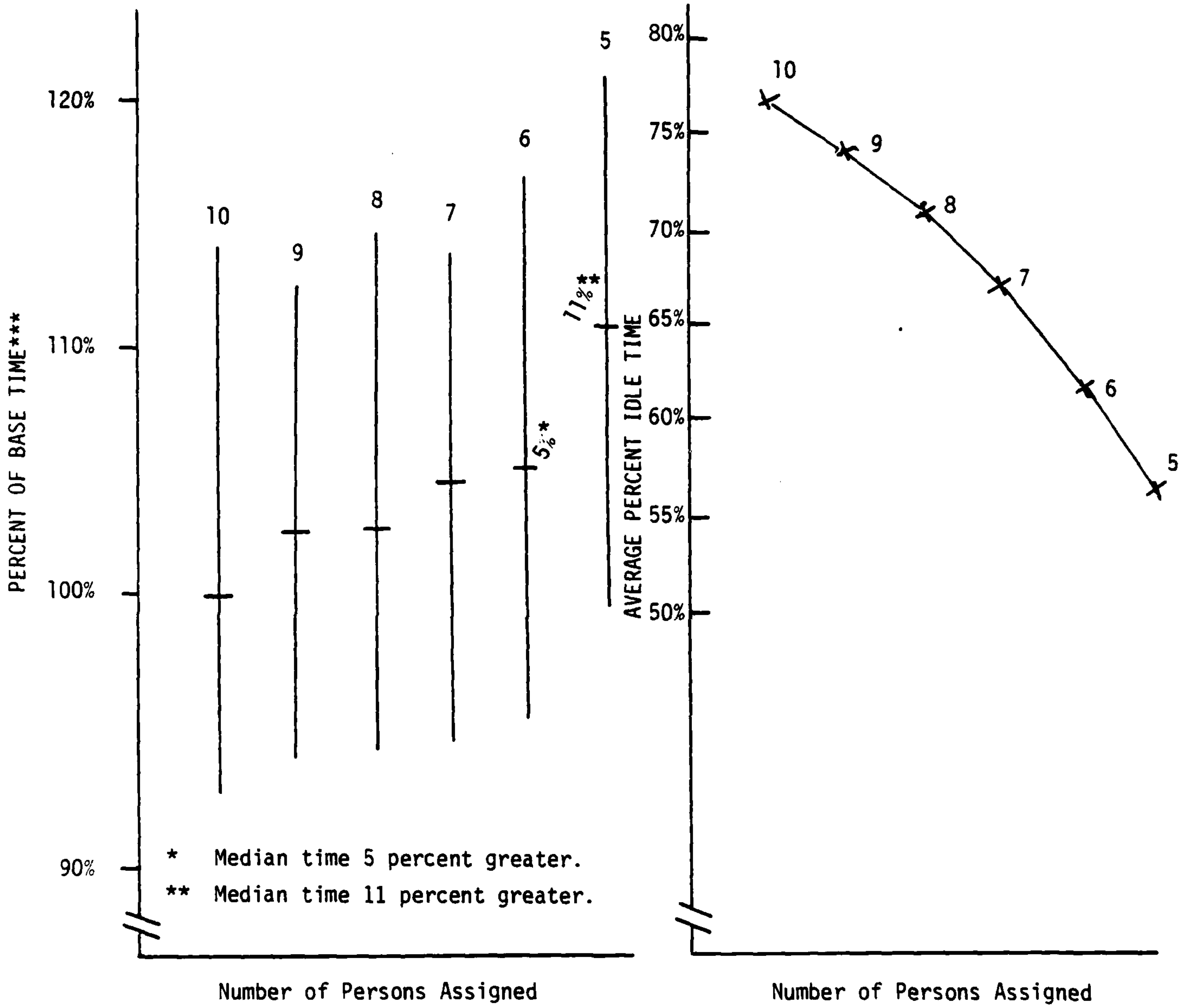

FIGURE 1-1. TIME REQUIRED TO EMPLACE AND BORESIGHT AN M109A1 HOWITZER SECTION AND CREW MEMBER IDLE TIME FOR VARIOUS NUMBERS OF ASSIGNED PERSONS.[2]

*** Expressed as a percent of the median time for a ten man group.

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[2] Ibid, page 24

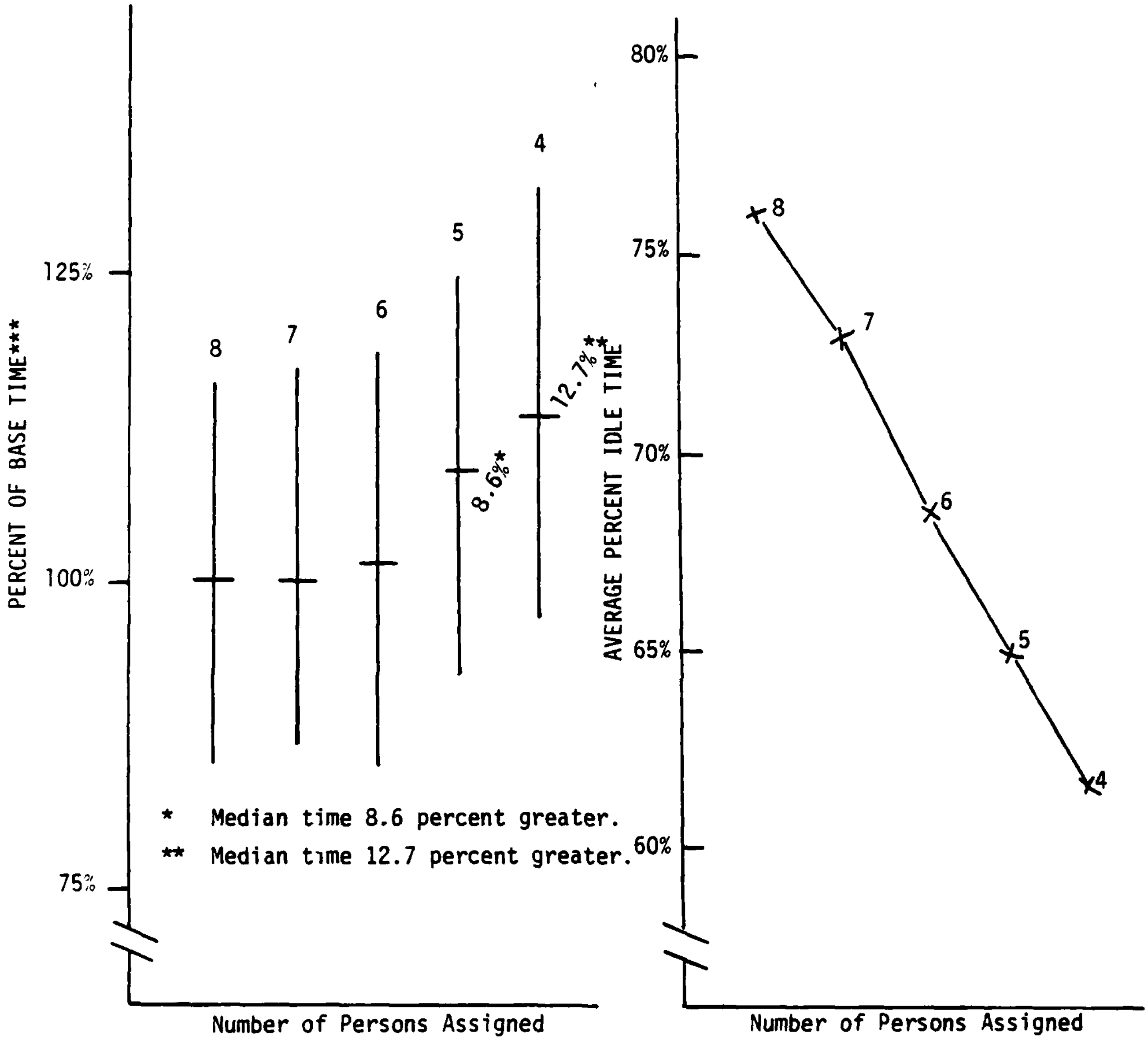

FIGURE 1-2. RELATIVE TIME REQUIRED TO FIRE A ONE-ROUND MISSION AND CREW MEMBER IDLE TIME FOR VARIOUS NUMBERS OF ASSIGNED PERSONS.[3]

*** Expressed as a percent with the median time for an eight man group as 100%

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3 Ibid, page 23

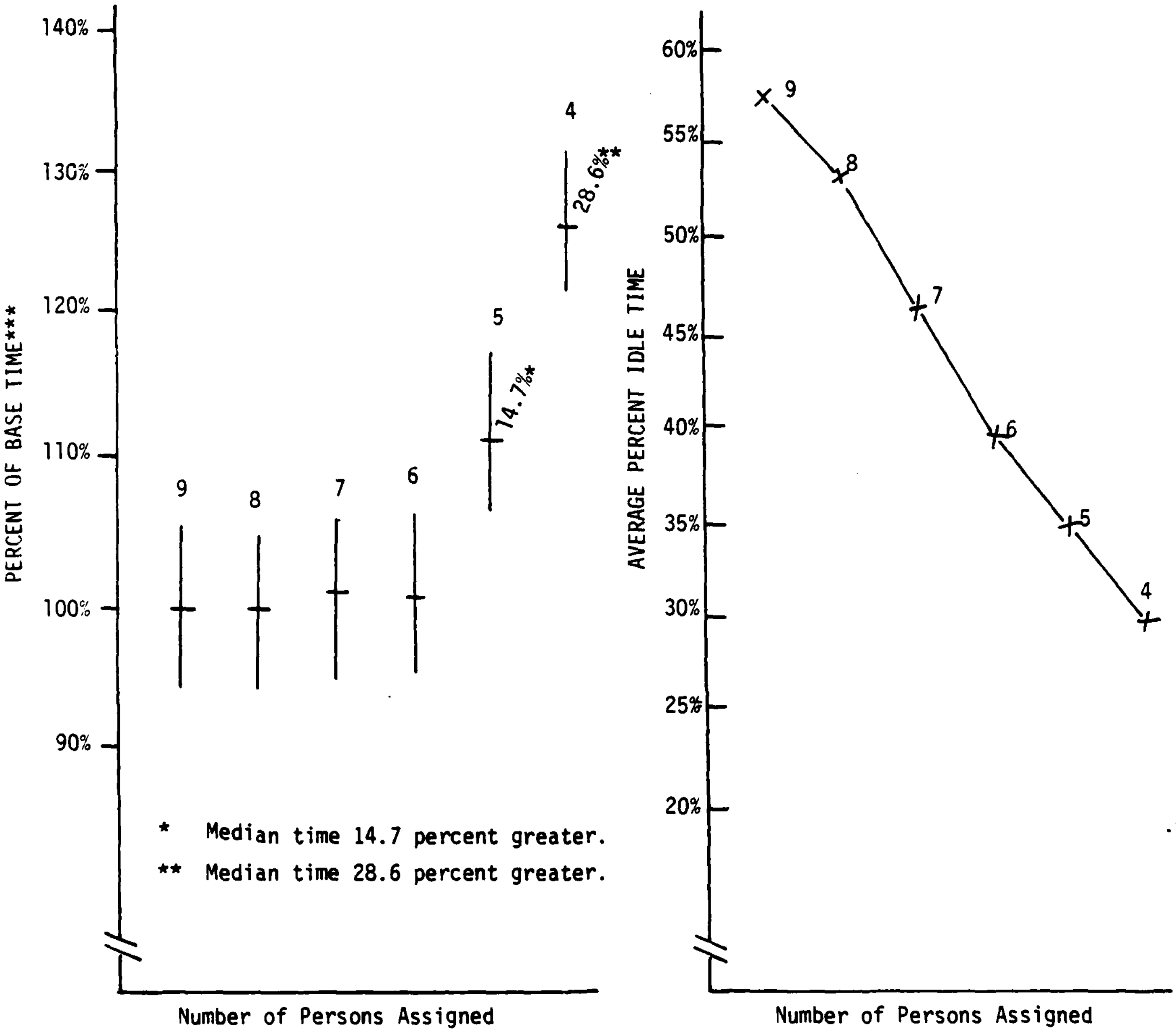

FIGURE 1-3. TIME REQUIRED TO MARCH ORDER AN M109A1 HOWITZER SECTION AND CREW MEMBER IDLE TIME FOR VARIOUS NUMBERS OF ASSIGNED PERSONS.[4]

*** Expressed as a percent of the median nine man performance time.

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[4] Ibid, page 25

ARI concluded that a reorganization of the section and a redistribution of the duties of crew members are required if the howitzer section is to train in peacetime the way it will be required to operate in wartime.

The derived model data showed that the median time required to emplace, fire or march order an M109A1 howitzer section increases only slightly up to a point as the number of crew members assigned to those duties decreases from the Technical Manual manning level. For example, with a five man firing unit plus a gun guide for displacements, emplacement, including boresighting, took 5 percent longer than the ten man Technical Manual method; firing a one-round mission took 8.5 percent longer; and, march ordering took 14.7 percent longer. Further analysis of the data showed that the longer firing times could be shortened to below the eight man firing times with minor equipment changes and that much of the 14.7 percent march order difference is an artifact due to the Technical Manual assumption that all crew members, except the gun guide, are at the weapon each time a march order begins.

Other analyses showed that as the number of crew members assigned to emplace/fire/march order is decreased from 10/8/9 to 5/5/5 the number of man hours available each day for support tasks increases from approximately 48-man hours to 120-man hours. Since support tasks could be extensive enough to require more than 129 man-hours/day/section, particularly during high fire rate (400-500 rounds per section) days, using the ten man crew as two five man units (5/5) appears to be a viable organizational alternative.

1.2 PURPOSE

The purpose of the present research effort is to analyze and compare the capability of alternative Division-86 155mm howitzer battery organizations following combat degradation.

1.3 METHOD

The alternative organizations are structured to provide timely and adequate fire support over extended periods of continuous combat while permitting adequate support man-hours for replenishment and risk reduction tasks during periods of highest demand for artillery fire. The analysis and comparison is conducted using the Analyses of Military Organizational Effectiveness (AMORE) model which measures the reconstitution capability of a unit with respect to time following enemy attack or degradations in personnel and materiel capability caused by other phenomena. For more information on the AMORE methodology, the reader is referred to "The AMORE answer to the ready-or-not question," A. Golub, Defense Management Journal, 1981, 1st Qtr, 30-37.

SECTION II

DEVELOPMENT OF INPUT DATA

SECTION II
DEVELOPMENT OF INPUT DATA

2.1 GENERAL

This section presents a compendium of the input data used in the AMORE analysis of alternative 155mm M109A1 howitzer section/battery organizations and where appropriate, the rationale used in developing those data. The input data described in this section and used in the analysis were staffed with force structure personnel of the Combat Developments Directorate of the US Army Field Artillery School. Input data used for sensitivity analysis will be presented in the sensitivity analysis section (Section IV).

The Table of Organization and Equipment (TOE) used for these analyses is the Division-86 155mm howitzer battery TOE 6-367J. The battery is comprised of 129 personnel, organized as shown in Table 2-1. There are eight howitzer sections in the battery capable of operating in either a consolidated battery configuration or as separate four gun platoons, each with an associated platoon headquarters, fire direction center and ammunition section. Communications support for the battery, whether the battery is operating in the consolidated or two platoon configuration, is provided by the Communications Section. The Battery Headquarters Section provides normal command, food service, supply and NBC support. Significant items of equipment authorized by the TOE are displayed in Table 2-2. When the two tables are compared, it can be noted that there are six vehicles in the platoon headquarters but only four drivers. The shortfall would be overcome, as explained by Fort Sill TOE specialists, by two drivers being furnished either from the howitzer sections of the battery or from the service battery of the battalion.

2.2 PERSONNEL TRANSFER MATRIX

In order to compute the capability of a unit to reconstitute itself over time following some form of degradation, the AMORE methodology requires as input a statement of which personnel skills can substitute for other skills, given some time for orientation and minimal review of functions. This required information is presented in the form of a personnel transfer matrix. The transfer matrix for this analysis is shown at Table 2-3. The thirty-five skills present in the howitzer battery organization are arrayed in rows down the left hand side of the matrix and in columns across the top of the matrix. The diagonal containing zeroes running from the upper left of the matrix to the lower right shows that each individual can substitute for himself with zero time delay. Dashes in the matrix indicate that the personnel skill in that particular row cannot, or would not, substitute for the skill represented in the column (e.g., the cook in

TABLE 2-1. PERSONNEL, DIVISION-86 155MM HOWITZER BATTERY TOE 6-367J

SECTION	SKILL	RANK/ GRADE	MOS	NO.
BTRY HQS	BTRY CDR	CPT	13E00	1
	FIRST SGT	E-8	13YM5 (NC)	1
	FOOD SVC SGT	E-7	94B40 (NC)	1
	SPLY SGT	E-6	76Y40 (NC)	1
	NBC NCO	E-5	54E20 (NC)	1
	FIRST COOK	E-5	94B20	1
	ARMORER	E-5	76Y20	1
	COOK	E-4	94B10	2
	COOK	E-3	94B10	1
	VEH DVR	E-3	13B10	1
COMMO SECT	TAC COM CH	E-6	31V30 (NC)	1
	TAC WIRE OP CH	E-5	36K20 (NC)	1
	TAC WIRE OP SPEC	E-4	36K10	1
	TAC WIRE OP SPEC	E-3	36K10	1
2 FIR PLT HQ	PLT LDR	LT	13E00	2
	PLT SGT	E-7	13B40 (NC)	2
	VEH DVR	E-3	13B10	4
2 FDC	FIRE DIR OFF	LT	13E00	2
	CH FD CMPTR	E-6	13E30 (NC)	2
	SR FD SPEC	E-5	13E20 (NC)	2
	FD SPEC	E-4	13E10	2
	CP CARRIER DVR	E-4	13E10	2
	FD SPEC	E-3	13E10	4
8-HOW SECT	CH SECT	E-6	13B30 (NC)	8
	GUNNER	E-5	13B20 (NC)	8
	AMMO TM CH	E-5	13B20 (NC)	8
	CANNONEER/ ASSEMBLER	E-4	13B10	8
	AMMO SPT VEH DVR	E-4	13B10	8
	SP HOW DVR	E-4	13B10	8
	CANNONEER	E-3	13B10	32
2 AMMO SECT	SECT CH	E-6	13B30 (NC)	2
	AMMO SPEC	E-4	13B10	2
	AMMO HANDLER	E-3	13B10	2
	SR AMMO VEH OP	E-5	64C20	2
	AMMO VEH OP	E-4	64C10	4
				129

TABLE 2-2. EQUIPMENT, DIVISION-86 155MM HOWITZER BATTERY TOE 6-367J

SECTION	EQUIPMENT	NO.
BTRY HQ	Radio Set AN/VRC 46.	2
	TRK, Utility, 1/4 ton, w/e.	2
	TKK, Cargo, 2 1/2 ton, 6x6.	2
	TRLR, Cargo 1/4 ton, 2 whl.	2
	TRLR, Cargo, 1 1/2 ton, 2 whl.	1
	TRLR, Tank, Water, 400 gal.	1
COMMO SETC	TRK, Cargo, 1/14 ton, 6x6.	1
	TRL, Cargo, 3/4 ton, 2 whl.	1
FIR PLT HQ	Aiming Circle.	6
	Radio Set AN/VRC-46.	2
	TRK, Utility, 1/4 ton, 4x4.	2
	TRK, Cargo, 1 1/4 ton, 6x6.	2
	TRK, Cargo, 2 1/2 ton, 6x6.	2
	TRL, Cargo, 1/4 ton.	2
	TRL, Cargo, 1 1/2 ton, 2 wh.	2
2 FDC	Carrier, CP, Lt. Trk.	2
	Computer, Gun Direction	2
	FD Set Artillery.	4
	Gen Set, Gas Eng.	4
	Radio Set, AN/VRC-46.	6
8 HOW SECT	Carrier, Cargo, Trkd, 6 ton.	8
	How, Med, SP, 155mm.	8
2 AMMO SECT	GOER, 8 ton.	6
	TRL, AMMO, 1 1/2 ton, 2 whl.	6

TABLE 2-3. PERSONNEL TRANSFER MATRIX (DIVISION-86 155MM HOWITZER BATTERY)

FROM SKILL	TO SKILL 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1 BC 13E00	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2 1SGT 13Y5M	15	0	-	-	-	-	-	-	-	-	-	-	-	-	60	0	-	-	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-
3 FS SG 94B4C	-	60	0	30	-	0	-	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	-	-	-	-	60	-	-	15	-
4 SPLSG 76Y40	-	30	-	0	-	-	0	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	30	0	0	0	-	30	0	-	15	0
5 NBCSC 54E20	-	-	-	-	0	-	-	-	-	0	-	-	15	0	-	-	0	-	-	-	-	-	-	-	-	30	15	15	15	0	-	15	0	30	15
6 1STCK 94B10	-	-	0	-	-	0	-	0	0	-	-	-	30	15	-	-	0	-	-	-	-	-	-	-	-	60	30	30	30	15	-	30	15	60	30
7 ARM 76Y20	-	-	-	30	-	-	0	-	-	0	-	-	15	0	-	-	0	-	-	-	-	-	-	-	-	30	15	15	15	0	-	15	0	30	15
8 COOK 94B10	-	-	30	-	-	0	-	0	0	-	-	-	60	30	-	-	30	-	-	-	-	-	-	-	-	120	60	60	60	30	-	60	30	120	60
9 COOK 94B10	-	-	-	-	-	30	-	0	0	60	-	-	120	60	-	-	60	-	-	-	-	-	-	-	-	-	120	120	120	60	-	120	60	-	120
10 DRV 13E10	-	-	-	-	-	-	-	-	-	0	-	-	120	60	-	-	0	-	-	-	-	-	-	-	60	30	0	0	0	0	-	0	0	30	0
11 COMCH 31V30	-	60	-	-	-	-	-	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12 WIRCH 36K20	-	-	-	-	-	-	-	-	-	-	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13 WIRSP 36K10	-	-	-	-	-	-	-	-	-	0	30	0	0	0	-	-	0	-	-	-	-	-	-	-	-	120	60	60	60	30	-	60	30	120	60
14 WIRSP 36K10	-	-	-	-	-	-	-	-	-	0	-	30	0	0	-	-	0	-	-	-	-	-	-	-	-	-	120	120	120	60	-	120	60	-	120
15 PLLDR 13E00	0	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16 PLSGT 13E40	-	30	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-
17 DVR 13B10	-	-	-	-	-	-	-	-	-	0	-	-	120	60	-	-	0	-	-	-	-	-	-	-	60	30	0	0	0	0	-	0	0	30	0
18 FDOFF 13E00	60	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19 CHFDC 13E30	-	60	-	-	-	-	-	-	-	-	30	-	0	-	-	60	-	30	0	0	0	0	-	-	-	15	0	0	0	-	-	0	-	15	0
20 SRFDS 13E20	-	-	-	-	-	-	-	-	-	0	-	-	15	0	-	-	0	60	30	0	0	0	0	-	-	30	15	15	15	0	-	15	0	30	15
21 FD SP 13E10	-	-	-	-	-	-	-	-	-	0	-	-	30	15	-	-	0	-	60	30	0	0	0	-	-	60	30	30	30	15	-	30	15	60	30
22 CFDVR 13E10	-	-	-	-	-	-	-	-	-	0	-	-	30	15	-	-	0	-	60	30	0	0	0	-	-	60	30	30	30	15	-	30	15	60	30
23 FDSP 13E10	-	-	-	-	-	-	-	-	-	0	-	-	60	30	-	-	0	-	-	60	30	0	0	-	-	-	60	60	60	30	-	60	30	-	60
24 CH/S 13B50	-	60	-	-	-	-	-	-	-	-	-	-	-	-	60	0	-	-	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-	0	0
25 GUNN 13B20	-	-	-	-	-	-	-	-	-	0	-	-	30	15	-	30	0	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0
26 AMMCH 13B20	-	-	-	-	-	-	-	-	-	0	-	-	30	15	-	30	0	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0
27 C/ASY 13B10	-	-	-	-	-	-	-	-	-	0	-	-	60	30	-	-	0	-	-	-	-	-	-	30	15	0	0	0	0	0	30	0	0	0	0
28 SVDVR 13B10	-	-	-	-	-	-	-	-	-	0	-	-	60	30	-	-	0	-	-	-	-	-	-	30	15	0	0	0	0	0	30	0	0	0	0
29 SPDVR 13B10	-	-	-	-	-	-	-	-	-	0	-	-	60	30	-	-	0	-	-	-	-	-	-	30	15	0	0	0	0	0	30	0	0	0	0
30 CANN 13E10	-	-	-	-	-	-	-	-	-	0	-	-	120	60	-	-	0	-	-	-	-	-	-	-	60	30	0	0	0	0	-	0	0	30	0
31 AMMCH 13E30	-	60	-	-	-	-	-	-	-	-	-	-	-	-	-	30	-	-	-	-	-	-	-	0	0	0	0	0	0	-	0	0	-	0	0
32 AMMSP 13E10	-	-	-	-	-	-	-	-	-	0	-	-	60	30	-	-	0	-	-	-	-	-	-	30	15	0	0	0	0	0	30	0	0	0	0
33 AMHDL 13B10	-	-	-	-	-	-	-	-	-	0	-	-	120	60	-	-	0	-	-	-	-	-	-	-	60	30	0	0	0	0	-	0	0	30	0
34 VEHOP 64C20	-	-	-	-	-	-	-	-	-	0	-	-	30	15	-	-	0	-	-	-	-	-	-	-	-	60	30	30	30	15	30	0	0	0	0
35 VEHOP 64C10	-	-	-	-	-	-	-	-	-	0	-	-	60	30	-	-	0	-	-	-	-	-	-	-	-	120	60	60	60	60	60	0	0	0	0

row 8 could not substitute for the first sergeant in column 2 and the first sergeant in row 2 would not (although he could) substitute for the cannoneer in column 30). The rationale used for defining those substitutions, which were determined to be feasible, along with the associated times is as follows.

- Within the same three digit Military Occupational Speciality Code (MOSC) skill group (e.g., 13B), two grade substitutions both higher and lower were permitted with time delays to permit learning depending upon the sophistication of the skill being considered (e.g., less time is required within the 13B and 36K groups than within the 13E group).

- Between different skill groups of essentially equal sophistication (13B and 36K, 94B to 36K, 94B to 13B) substitutions to one grade higher, to the same grade, one grade lower and two grades lower were permitted with delay times of 120, 60, 30 and 15 minutes, respectively.

- From a skill group of greater sophistication to one of lesser sophistication (13E to 13B, 13E to 36K) substitutions to one grade higher, to the same grade, one grade lower and two grades lower were permitted with delays of 60, 30, 15 and 0 minutes, respectively.

- Substitutions from one career field to another higher skill career field requiring schooling or special training were not permitted (13B to 13E, 36K to 13E, 13E to 94B).

- Between career fields, neither the substitution of chiefs nor the substitution for chiefs was permitted.

- Implementation of the above guidelines resulted in an initial strawman. As exceptions to these guidelines, certain substitutions were permitted or rejected based upon the experience of the authors or guidance from the Field Artillery School. As an example of the former, substitution of the supply sergeant for the first sergeant was permitted. As an example of the latter, substitution from outside the skill group was not permitted for the howitzer section gunner, regardless of grade.

2.3 MATERIEL TRANSFER MATRIX

Although the primary emphasis of this particular analysis was on personnel skills, equipment substitutability is also considered by the AMORE methodology in arriving at the reconstitution capability of a unit over time following some form of degradation. A substitutability mapping was developed for equipment similar to the one previously described for personnel skills. The equipment substitutability matrix used throughout this analysis is presented in Table 2-4.

2.4 ALTERNATIVE HOWITZER SECTION ORGANIZATIONS

Seven alternative howitzer section organizations were considered in the AMORE analysis. The alternative organizations were structured to provide timely and adequate fire support over extended periods of continuous combat while permitting adequate support man hours for replenishment and risk reduction tasks. The analysis was designed to determine the capability of the alternative units with respect to time following enemy attack or degradations in personnel and materiel caused by other phenomena. These organizations are described briefly below and displayed in Tables 2-5 through 2-11 (paragraph 2.5).

- Base Case. Although analysis has shown that there are insufficient personnel (with crew duties as currently defined and as currently trained) to provide both war fighting capability and required replenishment and risk reduction support functions in an extended, high intensity combat environment, the current ten man howitzer section was considered as the Base Case Organization for the analysis.

- Alternative I. As an excursion, extrapolations were made from ARI developed support task data to determine the number of personnel which would be required in the howitzer section in order to perform both the required war fighting and the identified support tasks. It was determined that four additional cannoneers would be required. Thus, Alternative I is a fourteen man howitzer section. Even so, with duties as defined today, the section would be capable of sustained 24 hour per day operations only if cross training and the substitution of crew members for other members were permitted in order that the sleep and personal health and hygiene requirements of crew members could be satisfied. The Alternative I organization was analyzed within the currently prescribed 129 man battery strength to show battery capability and reconstitutability if all required fighting and support tasks were performed as the crew is currently trained.

TABLE 2-4. TRANSFER MATRIX FOR MATERIEL

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	AN/VRC-46	2	0	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.	.	.	0	.	.	.	.
2	1/4T TRK	2	.	0	.	.	.	.	0	.	.	.	0	0	.	.	.	.	.	.	.	.	.	.	.	.
3	2 1/2T TRK	2	.	0	0	.	.	.	0	.	.	.	0	0	0	.	.	.	.	.	.	.	0	.	0	.
4	1/4T TRLR	2	.	.	.	0	.	.	.	0	.	.	.	.	.	0	.	.	.	.	.	.	.	.	.	.
5	1 1/2T TRL	1	.	.	0	.	0	.	.	0	.	.	.	.	.	0	0	.	.	.	.	.	.	.	.	0
6	WATER TRLR	1	.	.	.	.	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7	1 1/4T TRK	1	.	0	0	.	.	.	0	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.	.	.
8	3/4T TRLR	1	.	.	.	0	0	.	.	0	.	.	.	.	.	0	0	.	.	.	.	.	.	.	.	0
9	AIMINGCIR	6	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10	AN/VRC-46	2	0	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.	.	.	0	.	.	.	.
11	1/4T TRK	2	.	0	.	.	.	.	0	.	.	.	0	0	.	.	.	.	.	.	.	.	.	.	.	.
12	1 1/4T TRK	2	.	0	0	.	.	.	0	.	.	.	0	0	0	.	.	0	.	.	.	.	.	.	.	.
13	2 1/2T TRK	2	.	0	0	.	.	.	0	.	.	.	0	0	0	.	.	.	.	.	.	.	0	.	.	.
14	1/4T TRLR	2	.	.	.	0	0	.	.	0	.	.	.	.	.	0	0	.	.	.	.	.	.	.	.	.
15	1 1/2T TRL	2	.	.	.	.	0	.	.	0	.	.	.	.	.	0	0	.	.	.	.	.	.	.	.	0
16	CP CARRIER	2	.	0	.	.	.	.	0	.	.	.	0	0	.	.	.	0	.	.	.	.	.	.	.	.
17	GUNDIRCPTR	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	.	.	.	.	.	.
18	FDSETARTY	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	.	.	.	.	.	.
19	GEN SET	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	.	.	.	.	.
20	AN/VRC-46	6	0	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.	.	.	0	.	.	.	.
21	SPTVEHTRKD	8	.	.	0	.	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.	0	.	0	.
22	SP HOW	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	.	.
23	GOER8T	6	.	.	0	.	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.	.	.	0	.
24	TRLAMMO	6	.	.	.	0	0	.	.	0	.	.	.	.	.	0	0	.	.	.	.	.	.	.	.	0

- Alternative II. The howitzer section organization deriving from the ARI analysis was the ten member section divided into two teams of five each with duties redefined accordingly. Organized in this way, with each team alternatively performing fighting and support tasks, there are sufficient personnel to perform all required functions with 5 percent[1], 8.6 percent[2], and 14.7 percent[3] increases in the times required to emplace, fire a one round mission, and march order, respectively.[4]

- Alternative III. Realizing that a Chief of Section performs more of a supervisory function than a labor function, Alternative III adds an E4, 13B10 to the howitzer section and organizes the section into a Chief of Section and two teams of five. Duties for the individual team members would be the same as for Alternative II. An eleven man section so organized should be better able to perform all required combat and support functions and might be preferred to Alternative II if personnel ceilings permit the addition of an E-4 to the howitzer battery TOE. If assignment shortfalls or combat or other degradations were to result in the strength of the Alternative III section being reduced from eleven to ten menbers, it could continue to perform using the same definition of individual crew duties used for Alternative II.

- Alternative IV. Another way of organizing a ten member howitzer section is with two teams of four, with duties suitably defined, with the Chief of Section a member of one of the teams and with the two remaining section personnel dedicated to support functions. The ARI analysis found that a team of four personnel could emplace, fire a one round mission and march order with time penalties of 11 percent[5], 12.7 percent[6],

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1 Ibid, page 26

2 Ibid, page 22

3 Ibid, page 26

4 These percentages are artificially high. Time penalties could be reduced or eliminated by modifying equipment and/or changing assumptions.

5 Ibid, page 26

6 Ibid, page 22

and 28.6 percent[7] respectively, when compared with todays howitzer section.[8] Under this alternative, the two dedicated individuals plus the four member team not currently performing combat functions would be available for support functions. Under this alternative, the two dedicated support personnel are considered essential members of the section.

- Alternative V. A second way to organize into teams of four is with two teams plus a Chief of Section. The tenth member of the current ten man section in this case is not considered an essential member of the howitzer section although it is easy to see the valuable contribution he can make toward the performance of security and other support tasks and as a substitute for combat casualties or other crew personnel shortages.

- Alternative VI. The final alternative considered carried the teams of four concept one step further by organizing the section into two teams of four, with one team including the Chief of Section. Similar to Alternative V, the additional two members of the current ten member section are not considered essential to the section organization but would be available for the performance of support functions and for substitution in the event of combat casualties or other howitzer section degradation.

2.5 MINIMUM ESSENTIAL PERSONNEL TEAMS (METS)

In order to compute unit reconstitution capability, the AMORE methodology requires the definition of team increments and the minimum essential personnel required to form those teams. Reconstitution capability is then defined by the number of teams which can be formed over time, following some form of degradation, by making permissable substitutions of skills. In the case of the howitzer battery, teams are defined in terms of howitzer sections. Tables 2-5 through 2-11 show the Minimum Essential Teams (METs) for personnel for each of the howitzer section alternatives described earlier. While the howitzer section organization itself changes between

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7 Ibid, page 26

8 Here again it is possible to reduce these time penalties.

TABLE 2-5. MET, BASE CASE, TEN MAN HOWITZER SECTION; DUTIES AS ASSIGNED TODAY; INADEQUATE SUPPORT

					HOWITZER SECTIONS AND SUBSECTIONS																							
					1			2			3			4			5			6			7			8		
					a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
BTRY HQ	BTRY CDR	1	CPT	13E00	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	FIRST SGT	1	E-8	13YM5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	FOOD SVC SGT	1	E-7	94B40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SPLY SGT	1	E-6	76Y40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	NBC NCO	1	E-5	54E20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FIRST COOK	1	E-5	94B20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ARMORER	1	E-5	76Y20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	COOK	2	E-4	94B10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	COOK	1	E-3	94B10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	VEH DVR	1	E-3	13B10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
COMMO SECT	TAC COMM CH	1	E-6	31V30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TAC WIRE OP CH	1	E-5	36K20(N/C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	TAC WIRE OP SP	1	E-4	36K10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TAC WIRE OP SP	1	E-3	36K10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 FIR PLT HQ	PLT LDR	2	LT	13E00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	PLT SGT	2	E-7	13B40(N/C)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	VEH DVR	4	E-3	13B10	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2 FDC	FIRE DIR OFF	2	LT	13E00	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CH FD CMPTR	2	E-6	13E30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR FD SPEC	2	E-5	13E20(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FD SPEC	2	E-4	13E10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CP CARRIER DVR	2	E-4	13E10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FD SPEC	4	E-3	13E10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 HOW SECT	CH/SECT	8	E-6	13B30(N/C)	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	GUNNER	8	E-5	13B20(N/C)	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	AMMO TM CH	8	E-5	13B20(N/C)	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	CANNONEER/ASSY	8	E-4	13B10	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	AMMO SPT VEH D	8	E-4	13B10	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	SP HOW DVR	8	E-4	13B10	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	CANNONEER	32	E-3	13B10	4	0	0	4	0	0	4	0	0	4	0	0	4	0	0	4	0	0	4	0	0	4	0	0
2 AMMO SECT	AMMO SECT CH	2	E-6	13B30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	AMMO SPEC	2	E-4	13B10	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	AMMO HDLR	2	E-3	13B10	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	SR AMMO VEH OP	2	E-5	64C20	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	AMMO VEHOP	4	E-4	64C10	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0

TABLE 2-6. MET, ALT I, FOURTEEN MAN HOWITZER SECTION; DUTIES AS ASSIGNED TODAY; ADEQUATE SUPPORT

					HOWITZER SECTIONS AND SUBSECTIONS 1			2			3			4			5			6			7			8		
					a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
BTRY HQ	BTRY CDR	1	CPT	13E00	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	FIRST SGT	1	E-8	13YM5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	FOOD SVC SGT	1	E-7	94B40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SPLY SGT	1	E-6	76Y40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	NBC NCO	1	E-5	54E20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FIRST COOK	1	E-5	94B20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ARMORER	1	E-5	76Y20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	COOK	2	E-4	94B10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	COOK	1	E-3	94B10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	VEH DVR	1	E-3	13B10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
COMMO SECT	TAC COMM CH	1	E-6	31V30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TAC WIRE OP CH	1	E-5	36K20(N/C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	TAC WIRE OP SP	1	E-4	36K10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TAC WIRE OP SP	1	E-3	36K10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 FIR PLT HQ	PLT LDR	2	LT	13E00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	PLT SGT	2	E-7	13B40(N/C)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	VEH DVR	4	E-3	13B10	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2 FDC	FIRE DIR OFF	2	LT	13E00	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CH FD CMPTR	2	E-6	13E30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR FD SPEC	2	E-5	13E20(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FD SPEC	2	E-4	13E10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CP CARRIER DVR	2	E-4	13E10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FD SPEC	4	E-3	13E10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 HOW SECT	CH/SECT	8	E-6	13B30(N/C)	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	GUNNER	8	E-5	13B20(N/C)	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	AMMO TM CH	8	E-5	13B20(N/C)	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	CANNONEER/ASSY	8	E-4	13B10	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	AMMO SPT VEH D	8	E-4	13B10	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	SP HOW DVR	8	E-4	13B10	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	CANNONEER	32	E-3	13B10	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0	4	4	0
2 AMMO SECT	AMMO SECT CH	2	E-6	13B30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	AMMO SPEC	2	E-4	13B10	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	AMMO HDLR	2	E-3	13B10	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	SR AMMO VEH OP	2	E-5	64C20	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	AMMO VEH OP	4	E-4	64C10	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0

TABLE 2-7. MET, ALT II, TEN MAN HOWITZER SECTION; TWO CREWS OF FIVE

					HOWITZER SECTIONS AND SUBSECTIONS																							
					1			2			3			4			5			6			7			8		
					a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
BTRY HQ	BTRY CDR	1	CPT	13E00	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	FIRST SGT	1	E-8	13YM5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	FOOD SVC SGT	1	E-7	94B40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SPLY SGT	1	E-6	76Y40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	NBC NCO	1	E-5	54E20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FIRST COOK	1	E-5	94B20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ARMORER	1	E-5	76Y20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	COOK	2	E-4	94B10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	COOK	1	E-3	94B10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	VEH DVR	1	E-3	13B10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
COMMO SECT	TAC COMM CH	1	E-6	31V30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TAC WIRE OP CH	1	E-5	36K20(N/C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	TAC WIRE OP SP	1	E-4	36K10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TAC WIRE OP SP	1	E-3	36K10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 FIR PLT HQ	PLT LDR	2	LT	13E00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	PLT SGT	2	E-7	13B40(N/C)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	VEH DVR	4	E-3	13B10	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2 FDC	FIRE DIR OFF	2	LT	13E00	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CH FD CMPTR	2	E-6	13E30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR FD SPEC	2	E-5	13E20(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FD SPEC	2	E-4	13E10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CP CARRIER DVR	2	E-4	13E10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FD SPEC	4	E-3	13E10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 HOW SECT	CS/C	8	E-6	13B30(N/C)	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	UC/C	8	E-5	13B20(N/C)	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0
	GUNNER	8	E-5	13B20(N/C)	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0
	GUNNER	8	E-4	13B10	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	CANNONEER	8	E-4	13B10	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	CANNONEER	8	E-4	13B10	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0
	HOW/SPT VEH DVR	32	E-3	13B10	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0
2 AMMO SECT	AMMO SECT CH	2	E-6	13B30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	AMMO SPEC	2	E-4	13B10	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	AMMO HDLR	2	E-3	13B10	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	SR AMMO VEH OP	2	E-5	64C20	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	AMMO VEH OP	4	E-4	64C10	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0

TABLE 2-8. MET, ALT III, ELEVEN MAN HOWITZER SECTION; C/S AND TWO CREWS OF FIVE

					HOWITZER SECTIONS AND SUBSECTIONS																							
					1			2			3			4			5			6			7			8		
					a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
BTRY HQ	BTRY CDR	1	CPT	13E00	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	FIRST SGT	1	E-8	13YM5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	FOOD SVC SGT	1	E-7	94B40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SPLY SGT	1	E-6	76Y40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	NBC NCO	1	E-5	54E20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FIRST COOK	1	E-5	94B20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ARMORER	1	E-5	76Y20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	COOK	2	E-4	94B10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	COOK	1	E-3	94B10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	VEH DVR	1	E-3	13B10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
COMMO SECT	TAC COMM CH	1	E-6	31V30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TAC WIRE OP CH	1	E-5	36K20(N/C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	TAC WIRE OP SP	1	E-4	36K10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TAC WIRE OP SP	1	E-3	36K10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 FIR PLT HQ	PLT LDR	2	LT	13E00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	PLT SGT	2	E-7	13B40(N/C)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	VEH DVR	4	E-3	13B10	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2 FDC	FIRE DIR OFF	2	LT	13E00	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CH FD CMPTR	2	E-6	13E30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR FD SPEC	2	E-5	13E20(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FD SPEC	2	E-4	13E10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CP CARRIER DVR	2	E-4	13E10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FD SPEC	4	E-3	13E10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 HOW SECT	C/S	8	E-6	13B30(N/C)	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	UC/C	8	E-5	13B20(N/C)	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0
	UC/C	8	E-5	13B20(N/C)	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	GUNNER	8	E-4	13B10	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0
	GUNNER	8	E-4	13B10	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	CANNONEER	16	E-4	13B10	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0
	HOW/SPT VEH DVR	32	E-3	13B10	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0	2	2	0
2 AMMO SECT	AMMO SECT CH	2	E-6	13B30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	AMMO SPEC	2	E-4	13B10	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	AMMO HDLR	2	E-3	13B10	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	SR AMMO VEH OP	2	E-5	64C20	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	AMMO VEH OP	4	E-4	64C10	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0

TABLE 2-9. MET, ALT IV, TEN MAN HOWITZER SECTION; TWO TEAMS OF FOUR PLUS TWO SUPPORT PERSONNEL

					HOWITZER SECTIONS AND SUBSECTIONS																							
					1			2			3			4			5			6			7			8		
					a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
BTRY HQ	BTRY CDR	1	CPT	13E00	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	FIRST SGT	1	E-8	13YM5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	FOOD SVC SGT	1	E-7	94B40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SPLY SGT	1	E-6	76Y40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	NBC NCO	1	E-5	54E20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FIRST COOK	1	E-5	94B20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ARMORER	1	E-5	76Y20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	COOK	2	E-4	94B10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	COOK	1	E-3	94B10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	VEH DVR	1	E-3	13B10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
COMMO SECT	TAC COMM CH	1	E-6	31V30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TAC WIRE OP CH	1	E-5	36K20(N/C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	TAC WIRE OP SP	1	E-4	36K10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TAC WIRE OP SP	1	E-3	36K10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 FIR PLT HQ	PLT LDR	2	LT	13E00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	PLT SGT	2	E-7	13B40(N/C)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	VEH DVR	4	E-3	13B10	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2 FDC	FIRE DIR OFF	2	LT	13E00	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CH FD CMPTR	2	E-6	13E30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR FD SPEC	2	E-5	13E20(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FD SPEC	2	E-4	13E10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CP CARRIER DVR	2	E-4	13E10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FD SPEC	4	E-3	13E10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 HOW SECT	CS/C	8	E-6	13B30(N/C)	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	UC/C	8	E-5	13B20(N/C)	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0
	GUNNER	8	E-5	13B20(N/C)	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0
	GUNNER	8	E-4	13B10	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	HOW DVR	8	E-4	13B10	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	HOW DVR	8	E-4	13B10	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0
	SPT VEHD/SPT PR	32	E-3	13B10	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2
2 AMMO SECT	AMMO SECT CH	2	E-6	13B30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	AMMO SPEC	2	E-4	13B10	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	AMMO HDLR	2	E-3	13B10	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	SR AMMO VEH OP	2	E-5	64C20	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	AMMO VEH OP	4	E-4	64C10	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0

TABLE 2-10. MET, ALT V, NINE MAN HOWITZER SECTION; C/S AND TWO TEAMS OF FOUR

					HOWITZER SECTIONS AND SUBSECTIONS																							
					1			2			3			4			5			6			7			8		
					a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
BTRY HQ	BTRY CDR	1	CPT	13E00	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	FIRST SGT	1	E-8	13YM5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	FOOD SVC SGT	1	E-7	94B40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SPLY SGT	1	E-6	76Y40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	NBC NCO	1	E-5	54E20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FIRST COOK	1	E-5	94B20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ARMORER	1	E-5	76Y20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	COOK	2	E-4	94B10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	COOK	1	E-3	94B10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	VEH DVR	1	E-3	13B10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
COMMO SECT	TAC COMM CH	1	E-6	31V30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TAC WIRE OP CH	1	E-5	36K20(N/C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	TAC WIRE OP SP	1	E-4	36K10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TAC WIRE OP SP	1	E-3	36K10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 FIR PLT HQ	PLT LDR	2	LT	13E00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	PLT SGT	2	E-7	13B40(N/C)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	VEH DVR	4	E-3	13B10	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2 FDC	FIRE DIR OFF	2	LT	13E00	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CH FD CMPTR	2	E-6	13E30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR FD SPEC	2	E-5	13E20(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FD SPEC	2	E-4	13E10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CP CARRIER DVR	2	E-4	13E10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FD SPEC	4	E-3	13E10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 HOW SECT	C/S	8	E-6	13B30(N/C)	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	GUNNER	8	E-5	13B20(N/C)	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0
	GUNNER	8	E-5	13B20(N/C)	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	CANNONEER #1	8	E-4	13B10	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0
	CANNONEER #1	8	E-4	13B10	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	HOW DVR	8	E-4	13B10	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0
	HOW/SV DVR	32	E-3	13B10	2	1	0	2	1	0	2	1	0	2	1	0	2	1	0	2	1	0	2	1	0	2	1	0
2 AMMO SECT	AMMO SECT CH	2	E-6	13B30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	AMMO SPEC	2	E-4	13B10	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	AMMO HDLR	2	E-3	13B10	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	SR AMMO VEH OP	2	E-5	64C20	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	AMMO VEH OP	4	E-4	64C10	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0

TABLE 2-11. MET, ALT VI, EIGHT MAN HOWITZER SECTION; TWO TEAMS OF FOUR EACH

					HOWITZER SECTIONS AND SUBSECTIONS																							
					1			2			3			4			5			6			7			8		
					a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
BTRY HQ	BTRY CDR	1	CPT	13E00	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	FIRST SGT	1	E-8	13YM5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	FOOD SVC SGT	1	E-7	94B40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SPLY SGT	1	E-6	76Y40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	NBC NCO	1	E-5	54E20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FIRST COOK	1	E-5	94B20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	ARMORER	1	E-5	76Y20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	COOK	2	E-4	94B10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	COOK	1	E-3	94B10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	VEH DVR	1	E-3	13B10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
COMMO SECT	TAC COMM CH	1	E-6	31V30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TAC WIRE OP CH	1	E-5	36K20(N/C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	TAC WIRE OP SP	1	E-4	36K10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TAC WIRE OP SP	1	E-3	36K10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 FIR PLT HQ	PLT LDR	2	LT	13E00	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	PLT SGT	2	E-7	13B40(N/C)	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	VEH DVR	4	E-3	13B10	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2 FDC	FIRE DIR OFF	2	LT	13E00	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CH FD CMPTR	2	E-6	13E30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SR FD SPEC	2	E-5	13E20(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FD SPEC	2	E-4	13E10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CP CARRIER DVR	2	E-4	13E10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FD SPEC	4	E-3	13E10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 HOW SECT	CS/C	8	E-6	13B30(N/C)	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	UC/C	8	E-5	13B20(N/C)	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0
	GUNNER	8	E-5	13B20(N/C)	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0
	GUNNER	8	E-4	13B10	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	HOW DVR	8	E-4	13B10	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	HOW DVR	8	E-4	13B10	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0
	SPT VEH DVR	32	E-3	13B10	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	0
2 AMMO SECT	AMMO SECT CH	2	E-6	13B30(N/C)	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	AMMO SPEC	2	E-4	13B10	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	AMMO HDLR	2	E-3	13B10	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	SR AMMO VEH OP	2	E-5	64C20	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	AMMO VEH OP	4	E-4	64C10	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0

alternatives, the remainder of the battery remains the same. Two overriding considerations governed the definition of Mission Essential Teams:

- The howitzer battery and section must be capable of 24 hour per day operations.

- The battery must be capable of operating either from a consolidated location or from two separate platoon positions.

Having previously discussed the alternative howitzer section organizations, it remains to present the rationale for forming the remainder of the battery into METs. The following subparagraphs summarize the rationale.

- With the first howitzer section (team), there is a need for a minimal communications section, a fire direction center and one element of an ammunition section. With only a single howitzer section there is no need for either a platoon leader or a battery commander. Two drivers are included in the platoon headquarters, however, to drive the battery prescribed nuclear load (PNL) vehicles.

- With the addition of the second howitzer section it is necessary to add the platoon leader, platoon sergeant and driver. A second element of the ammunition section is also added.

- The addition of the third howitzer section requires only the addition of the remaining element of the first ammunition section while the addition of the fourth howitzer section requires no additions from the remainder of the battery.

- The battery commander, first sergeant and driver are added with the addition of the fifth howitzer section when the span of control capability of the first platoon leader begins to be exceeded.

- The second platoon leader, platoon sergeant, driver and a wireman are added with the sixth howitzer section when splitting the battery into two 3-gun platoons becomes a possibility.

- The addition of the three elements of the second ammunition section occurs with howitzer sections five, six and seven, respectively.

- No food service, supply or NBC personnel are considered essential at any team level.

2.6 MINIMUM ESSENTIAL MATERIEL TEAMS

As in the case of personnel, it is necessary to define the minimum essential materiel items required for each team of the unit. Table 2-12 shows the Minimum Essential Materiel Teams used throughout the analyses.

2.7 ADDITIONAL SIGNIFICANT INPUT DATA

Table 2-13 displays additional significant input data used during the analyses. The materiel damage was computed based on the number of rounds of enemy artillery required to inflict the designated level of personnel damage.

TABLE 2-12. MATERIEL MET: ALL ALTERNATIVES

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
BTRY HQS	RADIO SET AN/VRC	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	TRK, UTILITY, 1/4T, W/C	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	TRK, CARGO, 2 1/2T 6X6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TRLR, CARGO 1/4T 2WH	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	TRLR, CARGO 1 1/2T 2WH	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TRLR, TANK, WATER, 400 GAL	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COMMO SECT	TRK, CARGO 1 1/4T 6X6	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TRLR, CARGO 1/4T	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FR·PLT HQ	AIMING CIRCLE	6	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	RADIO SET AN/VRC-46	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	TRK, UTILITY, 1/4 T 4X4	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	TRK, CARGO, 1 1/4T 6X6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TRK, CARGO, 2 1/2T 6X6	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TRLR, CARGO, 1/4T	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	TRLR, CARGO, 1 1/2T 2WH	2	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
FD CTR	CARRIER, CP, LT TRK	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	COMPUTER, GUN DIRECTION	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FD SET ARTILLERY	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	GEN SET, GAS ENG	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RADIO SET, AN/VRC-46	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HOW SECT	CARRIER, CARGO, TRK 6T	8	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
	HOW, MED, SP, 155MM	8	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
AMMO SECT	TRK, CARGO, DROPSIDE, 5T 6X6	6	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0
	TRLR, AMMO, 1 1/2T 2WH	6	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0
	GOER, 8T																									

TABLE 2-13. ADDITIONAL SIGNIFICANT INPUT DATA

PROBABILITY OF DEGRADATION			
Personnel	10%	20%	30%
Materiel			
at least light damage	13%	31%	32%
at least moderate damage	8%	16%	22%
at least heavy damage	5%	10%	14%

SECTION III

ANALYSIS OF ALTERNATIVES

SECTION III
ANALYSIS OF ALTERNATIVES

3.1 GENERAL

The unit capability with respect to time was assessed for each of the seven alternative organizations described in Section II following personnel degradations of 0, 10, 20 and 30 percent and associated[1] levels of materiel degradation. Only the personnel degradations relate to the purpose of this research effort and are considered in this analysis. The results for each alternative will be presented first, followed by observations applicable to all alternatives.

3.2 ALTERNATIVE CASE RESULTS

3.2.1 General

The set of figures which follow display for each alternative case the maximum unit capability achieved after all permissible substitutions have been considered following the application of degradations of 0, 10, 20 and 30 percent to personnel (also 40, 50 and 60 percent in the case of Alternative II).[2] This capability is compared with the capability which could be expected of a unit organized such that the percent change in capability equals the percent change in resources (represented by the straight line). Inherent in a unit organized such that this relationship exists are three criteria:

- Maximum required personnel equals initial manning
- Demands for personnel are equal to capability level
- Surviving resources add to unit capability (another way of saying the unit is limited by population rather than by a shortage of specific skills).

3.2.2 Base Case (10-Man Howitzer Section; Duties as Today; Inadequate Support)

It can be seen in the base case results (Figure 3-1) that the initial manning somewhat exceeds or closely approximates the

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1 Based on JMEM analysis.

2 The influence of time after attack on capability is investigated in Section IV.

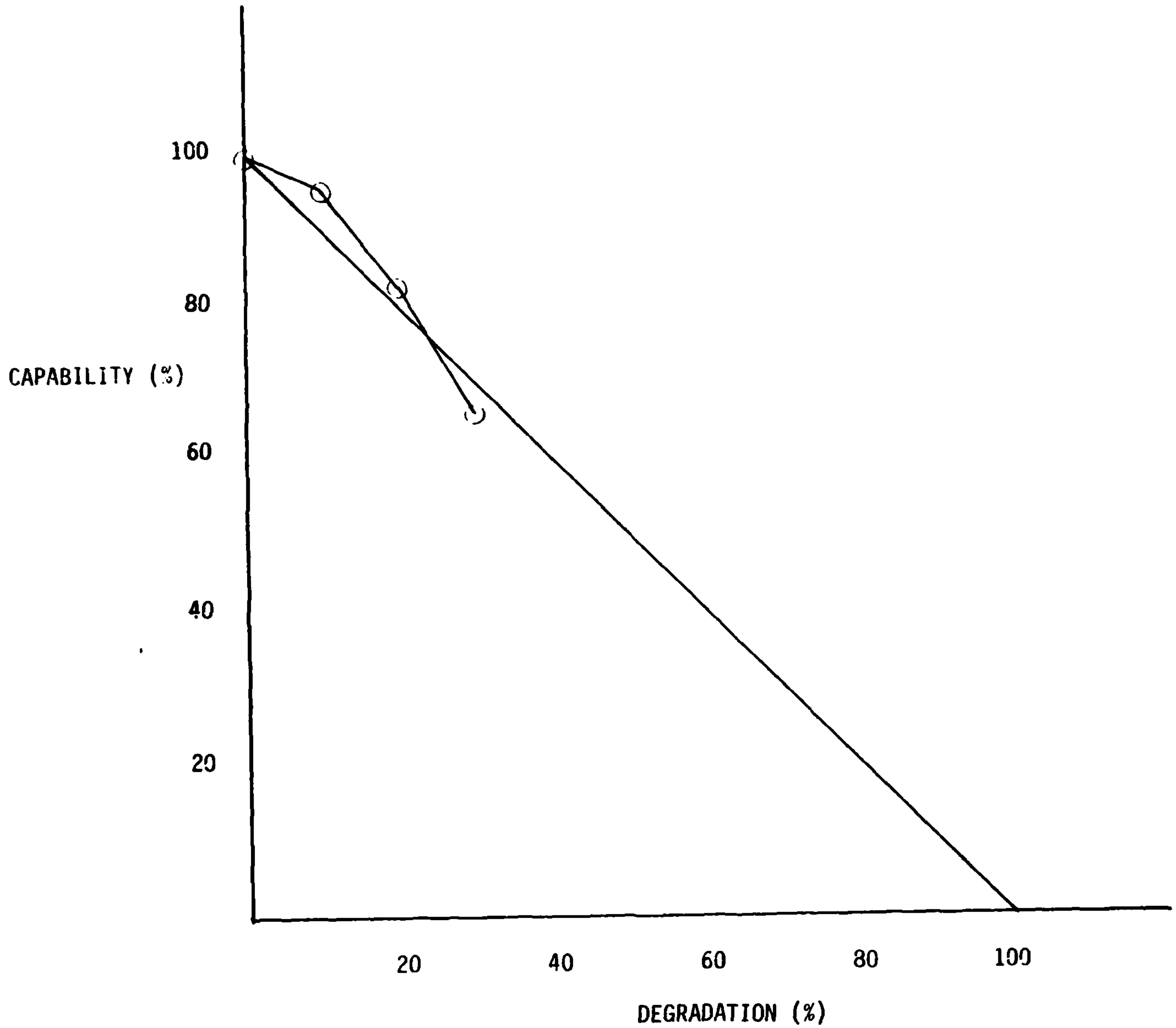

FIGURE 3-1. COMPUTED VERSUS EXPECTED CAPABILITY: BASE CASE (10 MAN HOW SECT; DUTIES AS TODAY; INADEQUATE SUPPORT)

required resources through the 25 percent degradation level. However, as the applied degradations exceed approximately 25 percent, the maximum capability the unit achieves after permissible substitutions have been considered begins to fall short of the effective organizational capability values. The key feature to bear in mind, however, is that with duties as assigned and taught today (10 men emplacing; 8 men firing; 9 men march ordering) the team capability is short lived, i.e., the duration over which a howitzer section could sustain continuous operations is severely limited. It would be impossible for the section to perform the support and replenishment tasks necessary for section survival and continued operations in addition to primary crew tasks. Two solutions to this problem are possible. The section can halt operations periodically to accomplish the required support tasks or section duties can be redistributed so that part of the section can be providing the required fire support while the other part of the section performs required support tasks to include eating and sleeping. The first option is clearly not practical. The second option offers the better solution and, in fact, is practiced today in spite of the fact that duties continue to be taught in accordance with the 10/8/9+GG philosophy. It is the two team solution with duties redistributed in accordance with crew size which ARI evaluated in their computer based modeling analyses. Battery capability results for various two team howitzer section organizations are shown in Figures 3-3 through 3-7 and are discussed in paragraphs 3.2.4 and 3.2.5.

3.2.3 Alternative I (14 Man Howitzer Section; Duties as Today; Adequate Support)

Before examining the two team howitzer section organizations, an additional look was taken at a howitzer section with crew duties as assigned today (10/8/9+GG) but with sufficient additional personnel in each howitzer section to accomplish the required support tasks. It was determined, using ARI defined support functions, that a fourteen member section would be required to perform both the fighting duties and support tasks during continuous firing operations. The accomplishment of the fighting duties would require the cross training of personnel so that substitutions could be made while crew members were taking care of personal functional requirements. It was decided that it would be unlikely that the battery strength would be increased by 32 personnel (4 men per howitzer section) so battery strength was retained at 129 personnel. Figure 3-2, then represents the capability of a battery where howitzer crew duties are assigned and crew members are trained as they are today and where personnel are substituted from other howitzer sections or elsewhere in the battery, as appropriate, to perform the support tasks required to permit 24 hours per day operations over extended periods of time. It can be seen from the figure that the computed capability lies considerably below the expected capability because required resources exceed manning. This is true even for the zero percent degradation case since there are sufficient

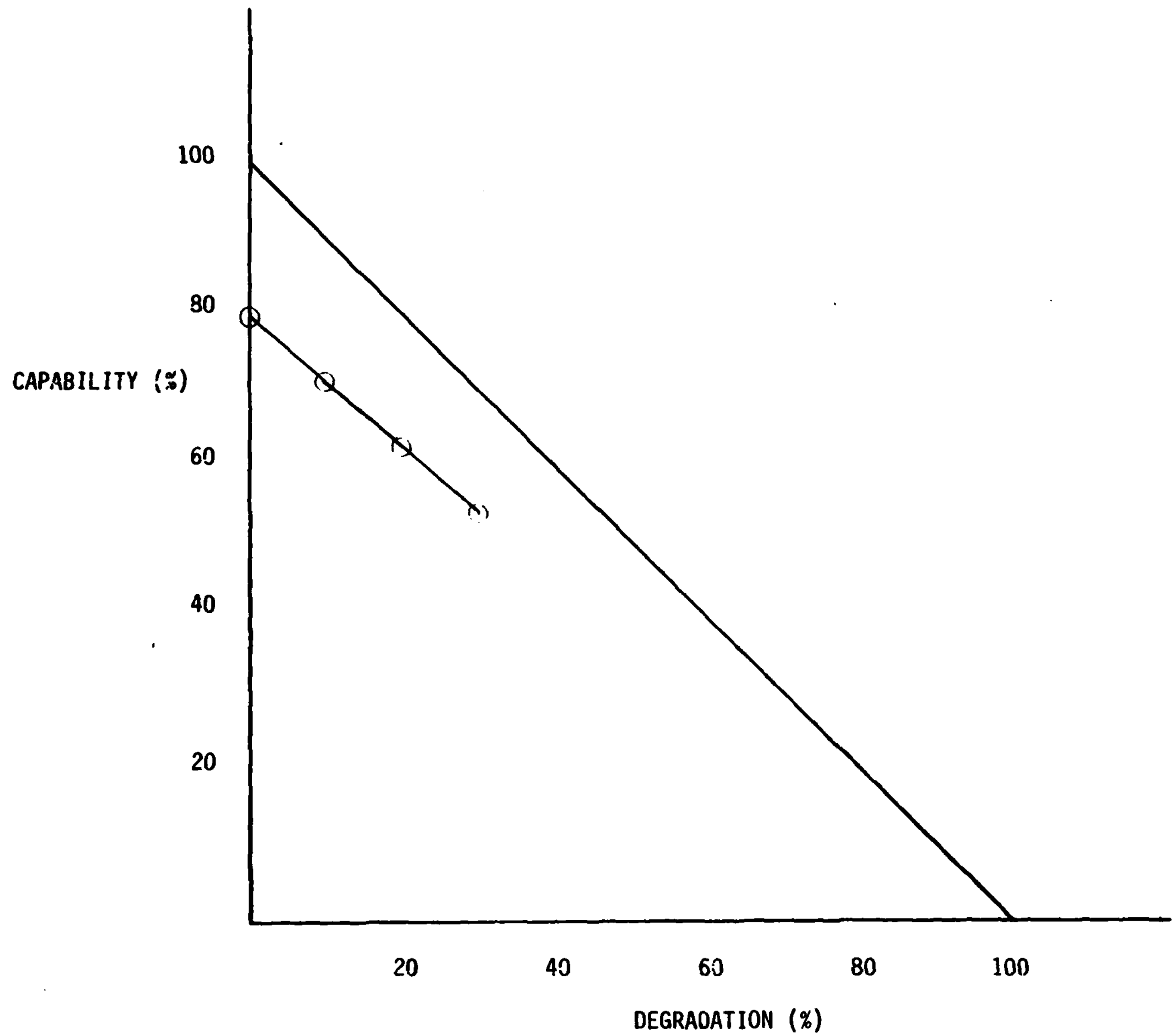

FIGURE 3-2. COMPUTED VERSUS EXPECTED CAPABILITY: ALTERNATIVE I (14 MAN HOW SECT; DUTIES AS TODAY; ADEQUATE SUPPORT)

personnel in the 129 member battery to man fully only six howitzer sections at the fourteen man level. This shortfall is the "cost" in capability of preserving the firing tasks as taught today while simultaneously performing needed support tasks.

3.2.4 Howitzer Sections Organized with Two Teams of Five Crewmen Each (Alternatives II and III)

Figures 3-3 (Alternative II: two teams of five, one of which includes the C/S) and 3-4 (Alternative III: C/S and two teams of five) show unit capabilities for alternative howitzer sections organized into two teams of five. In the case of Alternative III, the battery strength was increased by eight to 137 personnel to accommodate the increase in section strength from ten to eleven. If such an increase were possible, this organization would be preferred since it permits the C/S to be essentially a supervisor and does not require him to perform as a working leader. From the two figures, it can be seen that there is little difference between the capability of the howitzer section organized in two teams of five and today's howitzer section (Figure 3-1) in terms of numbers of teams which can be formed. But previous ARI analyses, summarized in Section I, revealed that the sections with two teams of five, although requiring 5 percent, 8.6 percent and 14.7 percent longer, respectively, to emplace, fire a one round mission and march order than todays ten man section, are able to perform required support tasks <u>and</u> provide fire support <u>continuously</u> over extended periods of time in an intense combat environment.

In the case of Alterntive II, additional degradations were tested to determine the impact on unit capability. It can be seen that as degradations increased, the unit capability deviated increasingly from the expected value line.

3.2.5 Howitzer Sections Organized with Two Teams of Four Crewmen Each (Alternatives IV, V and VI)

Figures 3-5 (Alternative IV: Two teams of four, one of which includes a C/S, plus two dedicated support personnel), 3-6 (Alternative V: C/S and two teams of four) and 3-7 (Alternative VI: Two teams of four, one of which includes the C/S) show the capabilities of batteries with howitzer sections organized in two teams of four. The results shown for Alternative IV are very similar to those shown for Alternatives II and III because the two dedicated support personnel are defined as essential members of the ten man section. This organizational alternative creates time penalties over base case mission times of 11 percent, 12.7 percent and 28.6 percent,[3] respectively, for emplacing, firing one round missions and march ordering without

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[3] Values derived from previous ARI analysis summarized in Section I.

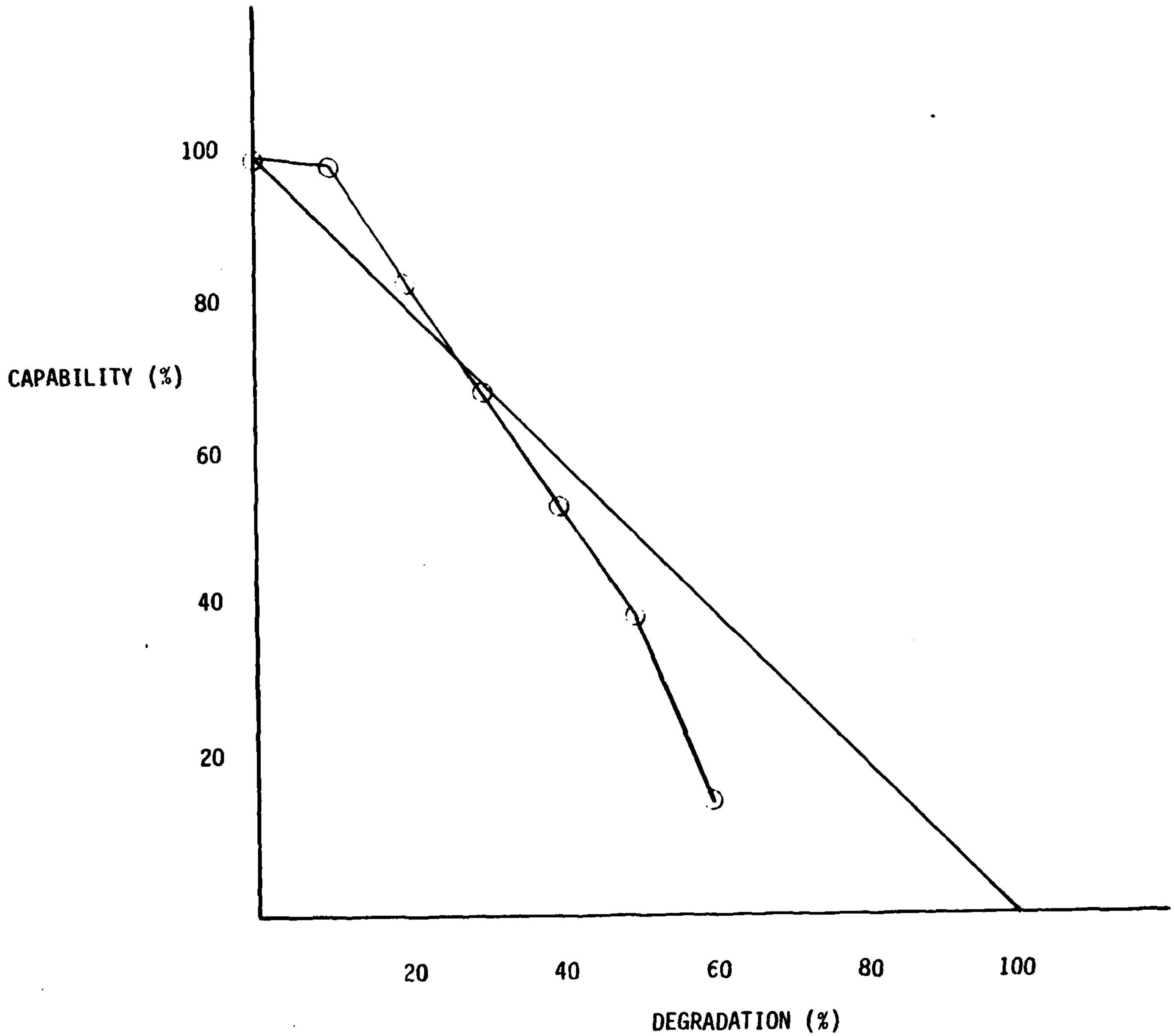

FIGURE 3-3. COMPUTED VERSUS EXPECTED CAPABILITY: ALTERNATIVE II (10 MAN HOW SECT; 2 TMS OF 5)

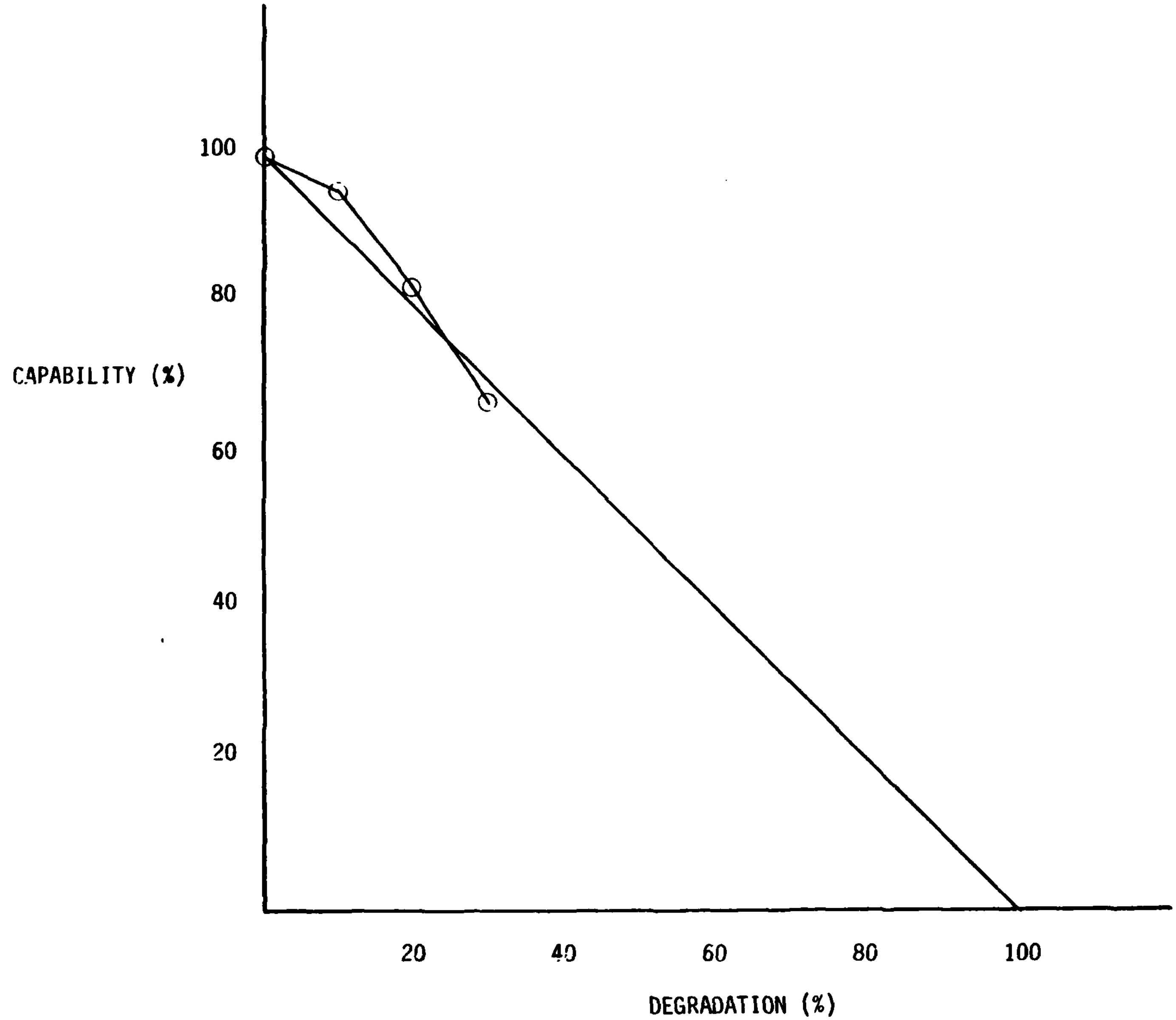

FIGURE 3-4. COMPUTED VERSUS EXPECTED CAPABILITY: ALTERNATIVE III (11 MAN HOW SECT; C/S AND 2 TMS OF 5)

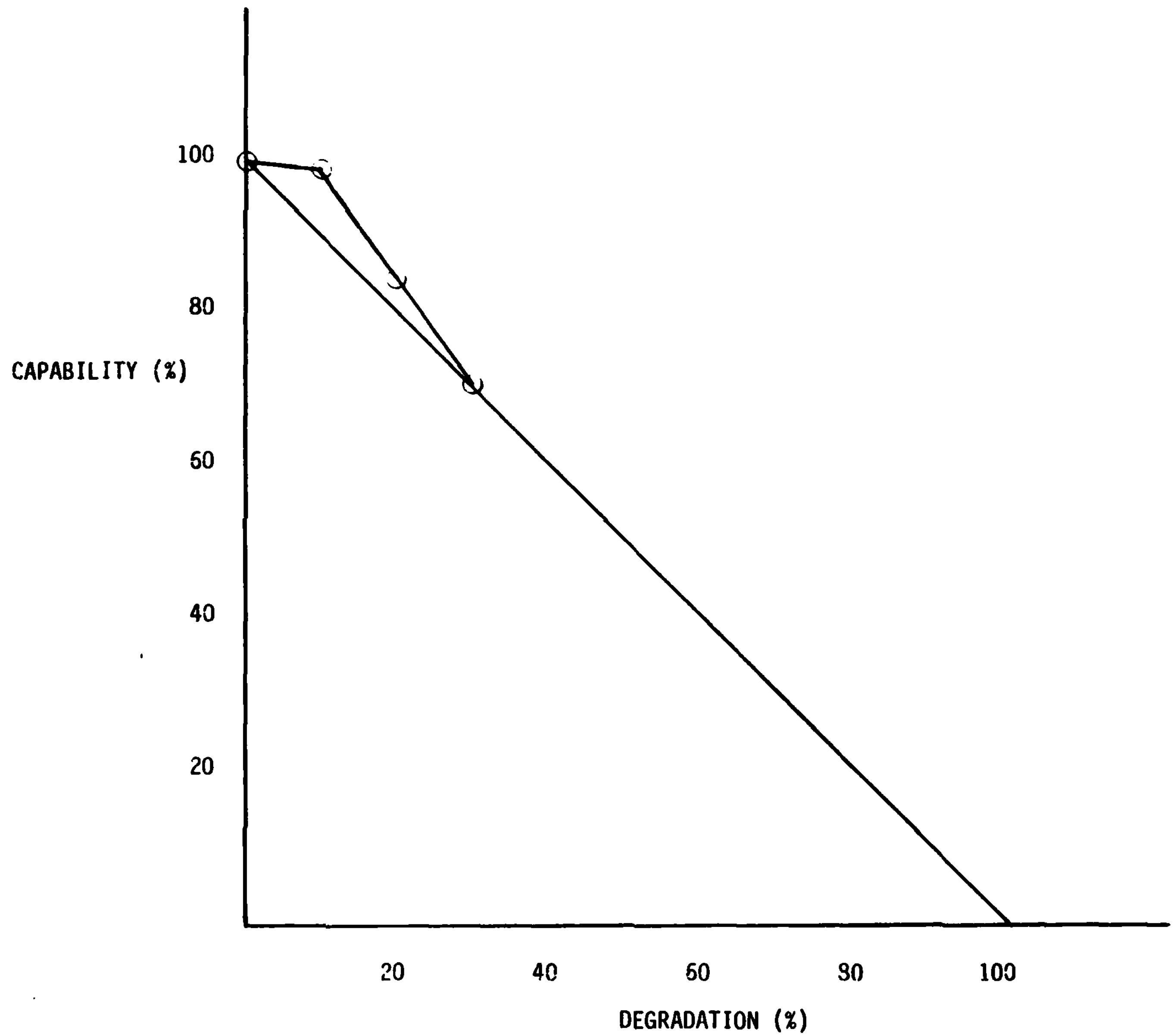

FIGURE 3-5. COMPUTED VERSUS EXPECTED CAPABILITY: ALTERNATIVE IV (10 MAN HOW SECT; 2 TMS OF 4; 2 SPT PERS)

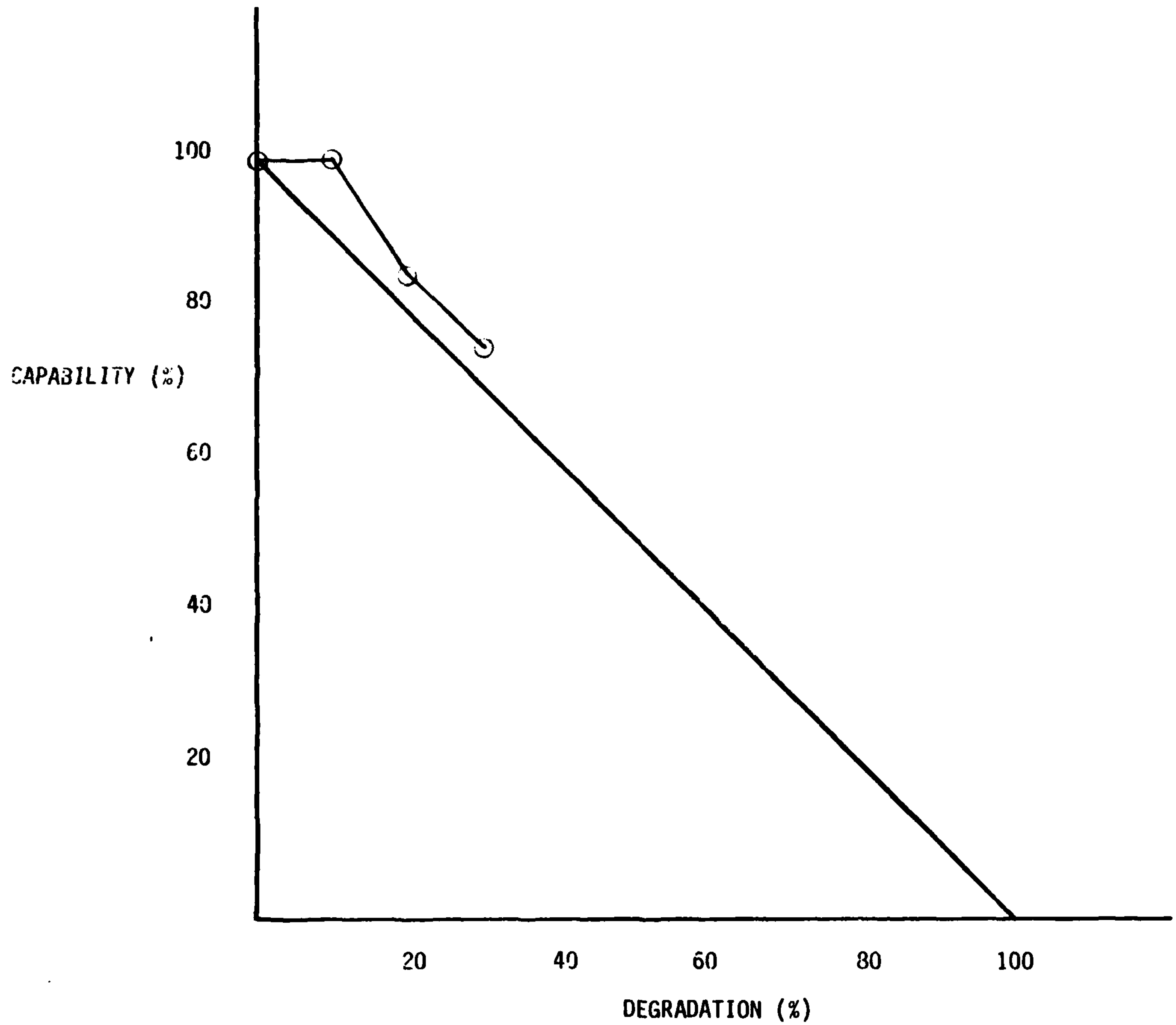

FIGURE 3-6. COMPUTED VERSUS EXPECTED CAPABILITY: ALTERNATIVE V (9 MAN HOW SECT; C/S AND 2 TMS OF 4)

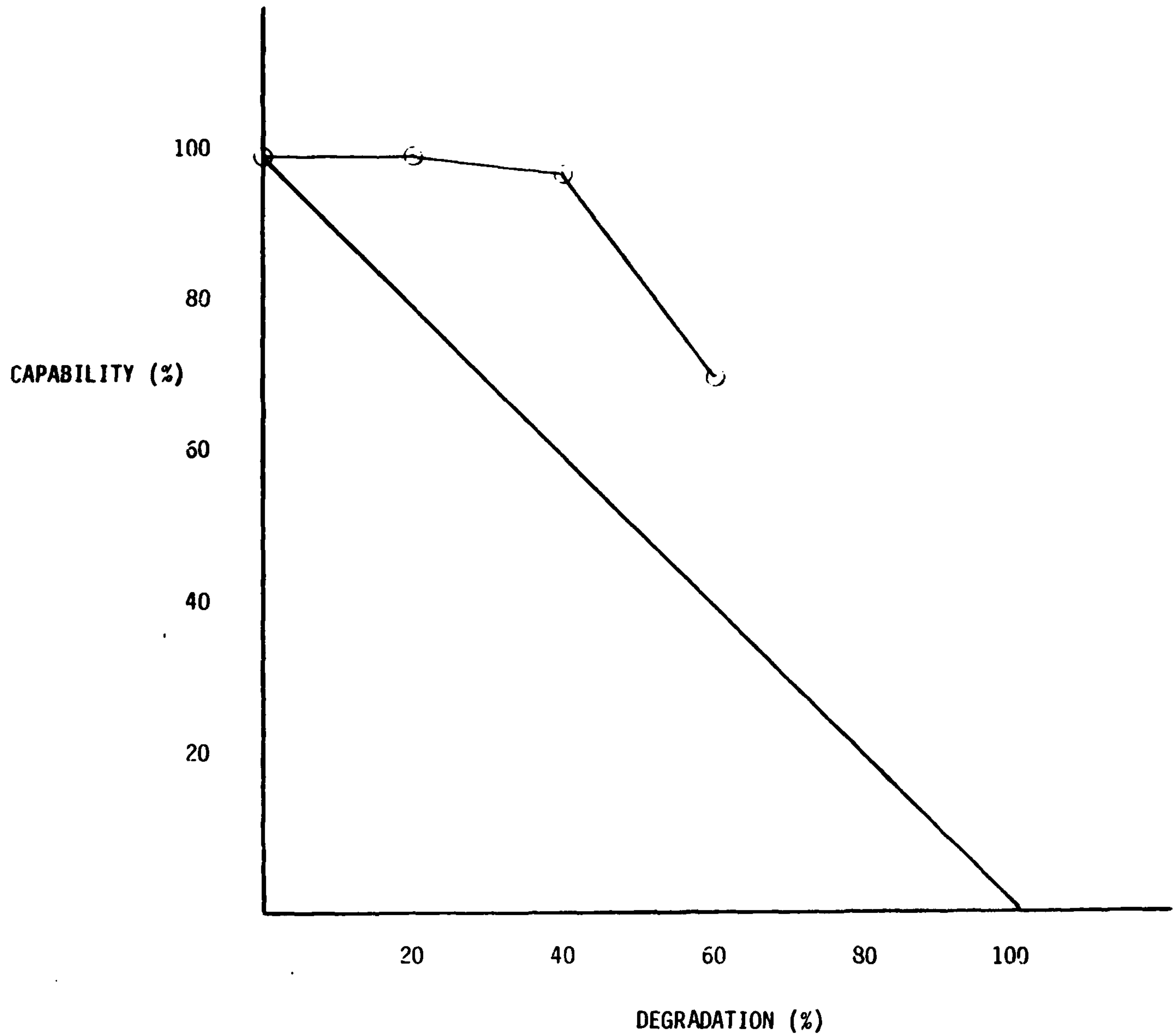

FIGURE 3-7. COMPUTED VERSUS EXPECTED CAPABILITY: ALTERNATIVE VI (8 MAN HOW SECT; 2 TMS OF 4)

attendant advantages in capability. As such, they exceed the firing costs of the two teams of five cases. In Alternatives V and VI, the same time penalties accrue to the two teams of four but there are compensating increases in capability as the one and two crewmen, respectively, not essential to the two teams are free to perform support tasks and substitute as required. As in the cases of two teams of five nearly all support tasks can be accomplished and continuous fire support (albeit somewhat less rapid) can be provided over extended periods of 24 hour per day intensive combat operations.

3.2.6 Direct Comparison

For direct comparison purposes, Figure 3-8 presents in a composite presentation (i.e., superimposed on the same axes) the capability versus degradation results for each of the seven organizational alternatives considered.

3.3 OBSERVATIONS

The following observations derive from the analysis:

- With rare exceptions associated with the random number draw for individual iterations, the howitzer battery under all organizational alternatives and degradations was found to be population limited rather than skill limited, i.e., all personnel were used in the substitution process and none were found to be surplus. While increases in the personnel assigned to a battery, in general, would result in increased capability, no unique skill exists, which if increased in number, would result in increased capability for the battery.

- The minimum essential team in each organizational alternative was defined with one fire direction center consisting of one half of the available fire direction center personnel. Although there is a requirement for operating from either a central battery location with one FDC or two platoon positions with two FDCs, it was decided that all howitzers would continue to function even if one of the two FDCs ceased to exist. There was concern, however, regarding whether there was any degradation or organizational case in which insufficient FDC personnel remained to form a second FDC capability, at least for finite periods of time. Examination indicated that at degradations up to 20 percent there were sufficient FDC personnel remaining to form a second FDC and still maintain at least a six howitzer section capability or more. At the 30 percent degradation level, where battery capability was six howitzer sections, or slightly less, it was still possible to

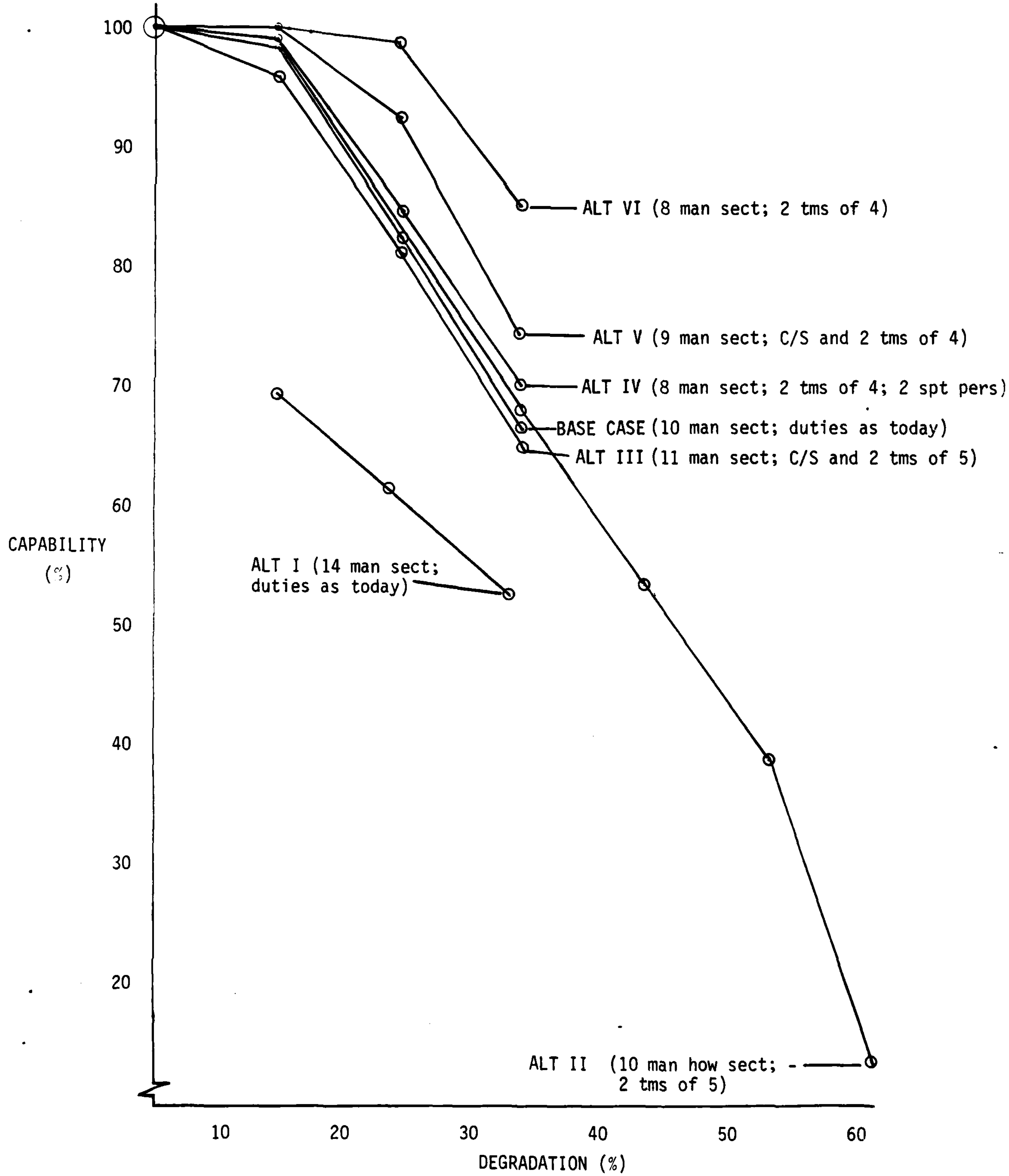

FIGURE 3-8. CAPABILITY VERSUS DEGRADATION FOR ALTERNATIVE ORGANIZATIONS

form at least a limited second FDC capability but only at the expense of a further slight reduction in battery capability as FDC personnel not needed for the first FDC but needed for the second were substituted for other essential battery skills.

- It is clear that the base case howitzer section as organized and trained today is unable to provide the simultaneous war fighting and support task capability required for continuous operations and that the allocation and training of crew duties should be revised. It also seems clear that there would be reluctance to add 32 personnel to the howitzer battery (4 per howitzer section) (Alternative I), dedicate two crewmen to support tasks (Alternative IV), or organize the howitzer section with either one or two supernumeraries (Alternatives V and VI, respectively). Furthermore, without supernumeraries, if a howitzer section were degraded below two teams of four, it would be virtually impossible to redefine and reassign the crew duties among the remaining crew members in any reasonable way which might result in the ability to provide timely fire support and survive. It appears, that the remaining organizational alternatives should be considered by the Army and that the selected alternative should form the basis for future howitzer section training.

  - If it were possible to add eight personnel to the howitzer battery (one to each howitzer section) the howitzer section organization comprised of the Chief of Section and two teams of five would be preferred. This organization provides the required war fighting and support task capability as well as the required supervisory functions.

  - If it is not possible to add a crewman to each howitzer section, then the second preferred alternative is the organization composed of two teams of five with the Chief of Section doubling as one of the team members. This alternative changes the C/S role slightly but it does provide the required war fighting and support capability. (Even if the preferred howitzer section organization with a Chief of Section and two teams of five were possible, the section should also train to function with only two teams of five in the event combat losses or personnel shortages caused by other reasons make it necessary to operate at that strength.)

- As pointed out earlier, the initial organization of the howitzer section into any version of two teams of four, without supernumeraries for substitution and for performing support tasks, is not practical because of the inadequate viability if the section is degraded below the four man level and because of the time penalties resulting from such austerity. Nevertheless, either of the organizations comprised of two teams of five should train to operate with teams of four against the eventuality that combat losses or other personnel shortages make it necessary to operate at those strengths.

SECTION IV

SENSITIVITY ANALYSIS

SECTION IV
SENSITIVITY ANALYSIS

4.1 OVERVIEW

The principal result documented in Section III was that the current allocation and teaching of tasks to artillery crewmen is unsatisfactory compared with possible alternative allocations. The current task allocation either does not permit necessary support tasks to be accomplished (thereby limiting capability) or requires four additional personnel per howitzer section to accomplish all tasks (thereby limiting capability when total battery personnel resources remain fixed). The alternatives considered to today's howitzer section organization include reallocations of tasks to howitzer sections comprised of two subteams of four or five men each. These alternatives provide a basis for accomplishing all support tasks while preserving the capability to accomplish mission tasks, albeit at some additional cost in time.

Several factors including battery TOE changes and tactical concepts were being implemented or questioned immediately prior to and during the period in which the crew capability AMORE research was being conducted. These included the following:

- The battery TOE strength had been reduced from 139 to 129 personnel (129 member organization was used in the previously reported analysis).
- The 64C MOS had been substituted for some 13B MOS in the ammunition section portion of the TOE (64C was used in previously reported analysis).
- Questions were raised as to whether the minimal threshold for splitting the battery for separate platoon operations should be three howitzer sections or two howitzer sections.

This section will document the investigation of the influence of the above factors on the capability of alternative howitzer sections organized with two subteams with either four or five men each

The method chosen for investigation is the Yates' method of Factorial Experimental Design. This method is documented and described in <u>Experimental Statistics</u>, National Bureau of Standards Handbook 91, August 1966, pages 12-1 to 12-9. A simple, yet complete, example of this technique is provided in Appendix A. Readers not familiar with the technique are invited to review the example in the Appendix prior to reading the discussion of its application to this analysis in the succeeding subsections.

The Factorial Sensitivity Application as reported in this section permits wide choices of measures of performance or measures of efficiency. By using a measure which combines the four or five team time penalties with the trade-off in numbers of section missions which could be fired in a given period, some insight is also gained on the relative influence or true cost of the time penalties identified by ARI for the two subteam cases (four or five men each).

4.2 FACTORS SELECTED

For this sensitivity analysis, five factors were selected. They are summarized in the table below and their impact is portrayed in detail in Figure 4-1.

Factor	Summary Meaning
A	From five to four men per team
B	From 10% to 30% attrition
C	From 129 to 139 personnel strength
D	From 3 howitzer to 2 howitzer split basis
E	From 64C MOS to 13B MOS as ammunition section drivers

Factors C and E were of interest because of recent changes directed in the 155mm Howitzer Battery TOE (139 to 129 personnel strength and MOS 13B to 64C for ammunition section drivers). Factor D was of interest to representatives of the Directorate of Combat Developments at Fort Sill.

Factor A incorporates the two alternatives shown in Section III to be more efficient than the current task allocation being taught.

Factor B was selected to define the likely region for peacetime and combat personnel strength and to serve as a control for comparing the effects of other factors. In peacetime, units are training for their wartime mission but are seldom, if ever, at TOE strength. In wartime, combat units under attack may find their strength at any time varying from 70 percent to 90 percent corresponding to attritions of 10 percent to 30 percent. These ranges are judged to be a more likely environment for unit mission performance than full strength.

FACTOR	BASE CASE	VARIATION	RELATED INPUT DATA CHANGES
A. HOWITZER SECTION ORGANIZATION	10 MAN SECTION; 2 TEAMS OF 5	8 MAN SECTION; 2 TEAMS OF 4	N/A
B. DEGRADATION	10%	30%	N/A
C. BATTERY STRENGTH	129	139	ADD TO TOE / ADD TO MET 1 COOK E-3 94B10 NO 1 TAC WIRE OP SP E-4 36K10 YES (TM6a) 2 VEH DVRS E-3 13B10 NO 2 SR FD SP E-5 13B20 YES (1)(TM1a) 4 AMMO HDLRS E-3 13B10 YES (2)(TM1a &5a)
D. PLATOON OPERATIONS	*SPLIT BTRY OPERATIONS W/NO LESS THAN 3 HOWITZERS PER PLATOON*	SPLIT BTRY OPERATIONS W/NO LESS THAN 2 HOWITZERS PER PLATOON	CHANGE SKILL / FROM TM / TO TM BTRY CDR 5a 4a 1st SGT 5a 4a VEH DVR 5a 4a TAC WIRE OP CH 6a 4a TAC WIRE OP SP 6a 4a (139 BTRY STR CASE ONLY) PLT LDR 6a 4a PLT SGT 6a 4a VEH DVR 6a 4a
E. MOSC OF AMMO SECT DVRS	64C (E-5 & E-4)	13B (E-5 & E-4)	13B E-5 & E-4 HAVE SAME SUBSTITUTABILITY AS HOWITZER SECTION E-5 & E-4

FIGURE 4-1. FACTORS SELECTED

Note that Figure 4-1 establishes as a sensitivity analysis base case, that case where none of the above factors are present, i.e.:

- Organization is two teams of five
- Degradation is 10 percent
- Strength is 129
- Battery can split into two platoons when no less than three howitzers can be manned per platoon
- 64C MOS personnel are assigned as ammunition section vehicle drivers.

To invoke the A factor merely requires going from a mission essential team (MET) requirement of two teams of five (as in Alternative II - Section III) to two teams of four (as in Alternative VI - Section III).

Adding factor B requires changing the AMORE attrition sampling percentage from 10 percent to 30 percent.

Invoking factor C (personnel strength from 129 to 139) implies two changes:

- Additions to the TOE as shown in Figure 4-1
- Additions to the MET as shown in Figure 4-1.

These changes tend somewhat to compensate for one another. As a result of the TOE increase, the MET is also increased. This infers slight change in the perceived way of accomplishing the mission.

Adding factor D involves a subtle change in the AMORE construct for the mission essential team (MET). This change reflects a potential tactical doctrine which would require at least four complete howitzer teams (two howitzers per platoon) to be present in order to operate as two separate platoons whenever factor D is present. When D is not present, three howitzers per platoon (for a total of six) must be present before the battery can split into two platoons. Both of these thresholds have an impact on the level of battery team capability where certain key personnel (e.g., Battery Commander, 1st Sergeant, platoon leaders) are required. "Required" means that in the AMORE sense, if the particular skill has not survived degradation and cannot be substituted for, then the capability level does not exist. Thus, in the current analysis, the impact of the D factor change in doctrine (three howitzers per platoon to two howitzers per platoon) is reflected in a change in the level at which specified skills are required. Figure 4-1 reflects these changes.

Finally, the presence of the E factor changes the composition of the battery manning. The impact of this change is not in numbers of personnel but rather in their revised capability to substitute. When the skills are 13B, they can substitute from the ammunition section into howitzer section 13B skills. When the skills are 64C, substitution times into the 13B MOSC are increased and substitutions are not permitted for either the Chief of Section or gunner. Thus the E factor tests whether this MOS shift makes a significant difference in battery resiliency.

It should be noted that presence of the C and E factors are tantamount to a return to the TOE which existed prior to recent changes. Thus, the negative of their effect is the impact of the TOE change.

4.3 IMPACT OF FACTORS ON CAPABILITY

Section III documented the analysis of task allocation based on capability as measured by AMORE simulations. This capability is defined as the expected ratio of the number of minimum essential teams which could be formed (by virtue of survivorship or substitution) to the total possible number of minimum essential teams in the battery. Thus, if an average of six teams could be restored following degradation then 6/8 or .75 would represent the expected capability. Capability measured in this fashion would range from zero to one.

Each of the five factors selected for the sensitivity analysis was varied in all possible combinations and produced the factored out results portrayed in Tables 4-1 and 4-2. These tables correspond to the formats described in Appendix A and illustrated by Tables A-1 and A-2, respectively.

In the second column of Tables 4-1 and 4-2, Relative Capability represents what was measured as a result of the AMORE runs for the factors and factor combinations as listed. The capability is team capability relative to a fully capable unit with eight teams.

Note that footnote "a" summarizes the meaning of the factors. From footnote "c," differences in capability greater than .013 are significant. This permitted drawing the significance dividing line as shown in Table 4-2.

From Table 4-2, an attrition change from 10 percent to 30 percent (factor B) resulted in the largest change in capability of .219. The change in capability resulting from factor A — two subteams of five skills each to two subteams of four skills each — had roughly one-third the impact of the attrition change (i.e., .076). The gain in capability (at a cost in mission times) of going to four skills per subteam is .076. Note that the combination of attrition increases and going from two subteams of five skills each to two subteams of

TABLE 4-1. CAPABILITY - 155mm (SP) HOW BTRY (DIV-86) - FACTORS

a/ FACTOR	RELATIVE CAPABILITY	PERCENT b/ OF HIGH	FACTOR c/ VALUE	PERCENT d/ OF HIGH
BASE	0.986	98.6 %	0.000	0.0 %
A	1.000	100.0 %	0.076	34.9 %
B	0.686	68.6 %	-0.219	-100.0 %
AB	0.853	85.3 %	0.066	30.0 %
C	1.000	100.0 %	0.019	8.7 %
AC	1.000	100.0 %	-0.012	-5.3 %
BC	0.701	70.1 %	0.008	3.8 %
ABC	0.856	85.6 %	-0.001	-0.4 %
D	0.975	97.5 %	-0.006	-2.9 %
AD	1.000	100.0 %	0.003	1.3 %
BD	0.679	67.9 %	-0.005	-2.4 %
ABD	0.819	81.9 %	0.002	0.9 %
CD	1.000	100.0 %	-0.002	-0.7 %
ACD	1.000	100.0 %	0.003	1.3 %
BCD	0.719	71.9 %	-0.002	-1.1 %
ABCD	0.853	85.3 %	0.004	1.8 %
E	0.975	97.5 %	0.004	2.0 %
AE	1.000	100.0 %	-0.003	-1.4 %
BE	0.689	68.9 %	0.005	2.5 %
ABE	0.835	83.5 %	-0.004	-1.8 %
CE	1.000	100.0 %	0.003	1.2 %
ACE	1.000	100.0 %	-0.004	-2.1 %
BCE	0.775	77.5 %	0.002	0.7 %
ABCE	0.856	85.6 %	-0.004	-1.6 %
DE	0.978	97.8 %	-0.002	-0.7 %
ADE	1.000	100.0 %	0.008	3.4 %
BDE	0.685	68.5 %	-0.003	-1.5 %
ABDE	0.850	85.0 %	0.009	4.2 %
CDE	1.000	100.0 %	-0.010	-4.5 %
ACDE	1.000	100.0 %	0.003	1.6 %
BCDE	0.703	70.3 %	-0.008	-3.7 %
ABCDE	0.851	85.1 %	0.002	0.8 %

a A FIVE TO FOUR MEN PER TEAM
  B 10 % TO 30 % ATTRITION
  C 129 TO 139 PENL STRENGTH
  D 3 HOW TO 2 HOW SPLIT BASIS
  E 64C TO 13B

b PERCENT OF HIGHEST MEASURED PERFORMANCE

c SIGNIFICANT FOR ABSOLUTE VALUE EXCEEDING .013

d PERCENT OF HIGHEST ABSOLUTE VALUE OF FACTORS (SIG 6.1%)

TABLE 4-2. CAPABILITY - 155mm (SP) HOW BTRY (DIV-86) - FACTORS ORDERED BY ABSOLUTE VALUE OF FACTORS

a/ FACTOR	RELATIVE CAPABILITY	PERCENT b/ OF HIGH	FACTOR c/ VALUE	PERCENT d/ OF HIGH
BASE	0.986	98.6 %	0.000	0.0 %
B	0.686	68.6 %	-0.219	-100.0 %
A	1.000	100.0 %	0.076	34.9 %
AB	0.853	85.3 %	0.066	30.0 %
C	1.000	100.0 %	0.019	8.7 %
AC	1.000	100.0 %	-0.012	-5.3 %
CDE	1.000	100.0 %	-0.010	-4.5 %
ABDE	0.850	85.0 %	0.009	4.2 %
BC	0.701	70.1 %	0.008	3.8 %
BCDE	0.703	70.3 %	-0.008	-3.7 %
ADE	1.000	100.0 %	0.008	3.4 %
D	0.975	97.5 %	-0.006	-2.9 %
BE	0.689	68.9 %	0.005	2.5 %
BD	0.679	67.9 %	-0.005	-2.4 %
ACE	1.000	100.0 %	-0.004	-2.1 %
E	0.975	97.5 %	0.004	2.0 %
ABE	0.835	83.5 %	-0.004	-1.8 %
ABCD	0.853	85.3 %	0.004	1.8 %
ABCE	0.856	85.6 %	-0.004	-1.6 %
ACDE	1.000	100.0 %	0.003	1.6 %
BDE	0.685	68.5 %	-0.003	-1.5 %
AE	1.000	100.0 %	-0.003	-1.4 %
ACD	1.000	100.0 %	0.003	1.3 %
AD	1.000	100.0 %	0.003	1.3 %
CE	1.000	100.0 %	0.003	1.2 %
BCD	0.719	71.9 %	-0.002	-1.1 %
ABD	0.819	81.9 %	0.002	0.9 %
ABCDE	0.851	85.1 %	0.002	0.8 %
BCE	0.775	77.5 %	0.002	0.7 %
DE	0.978	97.8 %	-0.002	-0.7 %
CD	1.000	100.0 %	-0.002	-0.7 %
ABC	0.856	85.6 %	-0.001	-0.4 %

a A FIVE TO FOUR MEN PER TEAM
B 10 % TO 30 % ATTRITION
C 129 TO 139 PSNL STRENGTH
D 3 HOW TO 2 HOW SPLIT BASIS
E 64C TO 13B

b PERCENT OF HIGHEST MEASURED PERFORMANCE

c SIGNIFICANT FOR ABSOLUTE VALUE EXCEEDING .013

d PERCENT OF HIGHEST ABSOLUTE VALUE OF FACTORS (SIG 6.1%)

four skills each had an additional positive impact on capability as reflected by the AB factored out interaction of .066. Thus, a four versus five men-per subteam composition tended to offset some of the attrition loss in capability. One key question is: At what level would it be prudent to shift from a five-man subteam to a four-man subteam requirement? A simple answer is whenever more teams are required and more teams can be built by relaxing the requirement. (It still remains to investigate the impact of the extra time penalty involved by relaxing the requirement to four men.)

A final significant result is due to the change in battery strength — factor C. When the battery TOE strength was reduced by 10 personnel to the strength of 129 used in the basic analysis, there was a corresponding reduction in minimum essential team requirements. The subsequent addition of personnel <u>and</u> MET requirements tended to cancel one another in terms of capability. Even so, it had a net positive effect on capability although the operational significance of .019 is not great.

It should be noted finally that two of the five factors did not have a significant impact on battery capability. These were:

- Factor D - the change in the threshold required for split battery operations, and
- Factor E - the change in MOS.

Recall (from Figure 4-1) that factor D required certain key personnel at different levels of capability. At the levels of attrition considered, this change in requirement never became a serious obstacle. At higher attrition levels factor D could be a problem.

Factor E had no severe impact because the lowered substitutability realized with the 64C MOS was compensated for by an otherwise rich spectrum of substitutability elsewhere in the battery. The unit never deviated from being population limited at the attrition levels investigated. Had the lesser substitutability associated with the 64C MOS caused the unit to be skill limited rather than population limited, then the impact on capability would have been significant.

4.4 IMPACT OF FACTORS ON AREA UNDER CURVE

The actual output of the AMORE runs include capability as a function of time. Capability increases to some restorable level as time constraints associated with substitution, movement and reaction become activated. Thus far we have examined capability at only one point, i.e., a sufficiently long time to realize final capability. Accordingly, the time dynamics of the restoration of capability have not been reflected in the analysis. This consideration suggests the following question: Does the incorporation of the time parameter influence what factors are significant?

One measure which incorporates the interactions of capability and time is the area under the AMORE curve up to some time horizon. This area measure has a physical interpretation. If a given point on the curve is the relative rate at which the unit can produce its product then the area under the curve to that point is the relative productivity of the unit. For some units, like an artillery unit, it suffices to state this measure in terms of unit hours. For example, if the relative productivity of a unit through one and one-half hours is one unit hour, then the productivity of that unit was limited to two thirds that of a fully capable unit.

In a full-up artillery unit of the type studied here, there are eight teams. If all teams operate over one and one-half hours then twelve team hours worth of productivity could have been achieved. One unit hour over the same period equates to eight team hours. In the next section we will carry this approach further to investigate one-round team missions which could be fired.

Clearly the more productive a unit can be following attack, the more resilient that unit is. It is that response we now investigate using team hours under the AMORE curve as a measure.

One and one-half hours was chosen as a time horizon because by that time the personnel teams have all reached a steady-state capability.

The following two tables (4-3 and 4-4) serve the same function at A-1 and A-2, respectively, in the example (Appendix A).

The inputs under the second column ("CREW HOURS") are the full crew hours of productivity available to the unit up to 1.5 hours for each factor combination investigated. (Recall a fully capable unit would have twelve team hours of productivity potential.)

From Table 4-4 the impact of the higher attrition level (factor B) is clearly dominating the productivity of the organization for the first one and one-half hours following attack.

The difference in personnel strength, while found significant for final capability level, was not a significant contributor to early potential productivity. The difference in strength impacted on the steady state but not the transient unit response. However, in the presence of higher attrition (factor B), it becomes significant (BC: -.368).

TABLE 4-3. AREA UNDER CURVE (TO 1.5 HRS) - 155mm (SP) - FACTORS

a/ FACTOR	CREW HOURS	PERCENT b/ OF HIGH	FACTOR c/ VALUE	PERCENT d/ OF HIGH
BASE	7.577	85.8 %	0.000	0.0 %
A	8.625	97.7 %	0.299	8.6 %
B	3.873	43.9 %	-4.625	-100.0 %
AB	3.757	42.5 %	-0.423	-9.1 %
C	7.997	90.5 %	-0.064	-1.4 %
AC	8.282	93.8 %	-0.174	-3.8 %
BC	3.179	36.0 %	-0.363	-8.0 %
ABC	2.883	32.6 %	0.008	0.2 %
D	6.945	78.6 %	-0.394	-8.5 %
AD	7.999	90.6 %	0.176	3.8 %
BD	3.437	38.9 %	0.067	1.5 %
ABD	3.309	37.5 %	0.147	3.2 %
CD	7.363	83.4 %	0.061	1.3 %
ACD	7.883	89.3 %	0.035	0.8 %
BCD	3.144	35.6 %	0.094	2.0 %
ABCD	3.071	34.8 %	-0.041	-0.9 %
E	7.277	82.4 %	-0.010	-0.2 %
AE	8.332	94.3 %	0.112	2.4 %
BE	3.753	42.5 %	-0.123	-2.7 %
ABE	3.501	39.6 %	0.018	0.4 %
CE	8.047	91.1 %	0.152	3.3 %
ACE	8.832	100.0 %	0.003	0.1 %
BCE	3.599	40.7 %	-0.058	-1.2 %
ABCE	2.880	32.6 %	-0.139	-3.0 %
DE	7.147	80.9 %	-0.015	-0.3 %
ADE	8.006	90.6 %	0.118	2.6 %
BDE	2.575	29.2 %	-0.127	-2.7 %
ABDE	3.641	41.2 %	0.150	3.2 %
CDE	7.485	84.7 %	-0.097	-2.1 %
ACDE	8.453	95.7 %	-0.022	-0.5 %
BCDE	2.657	30.1 %	-0.008	-0.2 %
ABCDE	2.984	33.8 %	-0.041	-0.9 %

a A FIVE TO FOUR MEN PER TEAM
  B 10 % TO 30 % ATTRITION
  C 129 TO 139 PSNL STRENGTH
  D 3 HOW TO 2 HOW SPLIT BASIS
  E 64C TO 13E
b PERCENT OF HIGHEST MEASURED PERFORMANCE
c SIGNIFICANT FOR ABSOLUTE VALUE EXCEEDING .226
d PERCENT OF HIGHEST ABSOLUTE VALUE OF FACTORS (SIG 4.9%)

TABLE 4-4. AREA UNDER CURVE (TO 1.5 HRS) - 155mm (SP) - FACTORS ORDERED BY ABSOLUTE VALUE OF FACTORS

a/ FACTOR	CREW HOURS	PERCENT b/ OF HIGH	FACTOR c/ VALUE	PERCENT d/ OF HIGH
BASE	7.577	85.8 %	0.000	0.0 %
B	3.878	43.9 %	-4.625	-100.0 %
AB	3.757	42.5 %	-0.423	-9.1 %
A	8.625	97.7 %	0.399	8.6 %
D	6.945	78.6 %	-0.394	-8.5 %
BC	3.179	36.0 %	-0.368	-8.0 %
AD	7.999	90.6 %	0.176	3.8 %
AC	8.282	93.8 %	-0.174	-3.8 %
CE	8.047	91.1 %	0.152	3.3 %
ABDE	3.641	41.2 %	0.150	3.2 %
ABD	3.309	37.5 %	0.147	3.2 %
ABCE	2.880	32.6 %	-0.139	-3.0 %
BDE	2.575	29.2 %	-0.127	-2.7 %
BE	3.753	42.5 %	-0.123	-2.7 %
ADE	8.006	90.6 %	0.118	2.6 %
AE	8.332	94.3 %	0.112	2.4 %
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BCD	3.144	35.6 %	0.094	2.0 %
BD	3.437	38.9 %	0.067	1.5 %
C	7.997	90.5 %	-0.064	-1.4 %
CD	7.368	83.4 %	0.061	1.3 %
BCE	3.599	40.7 %	-0.053	-1.2 %
ABCDE	2.984	33.8 %	-0.041	-0.9 %
ABCD	3.071	34.8 %	-0.041	-0.9 %
ACD	7.883	89.3 %	0.035	0.8 %
ACDE	8.453	95.7 %	-0.022	-0.5 %
ABE	3.501	39.6 %	0.018	0.4 %
DE	7.147	80.9 %	-0.015	-0.3 %
E	7.277	82.4 %	-0.010	-0.2 %
ABC	2.883	32.6 %	0.008	0.2 %
BCDE	2.657	30.1 %	-0.008	-0.2 %
ACE	8.832	100.0 %	0.003	0.1 %

a A FIVE TO FOUR MEN PER TEAM
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c SIGNIFICANT FOR ABSOLUTE VALUE EXCEEDING .226
d PERCENT OF HIGHEST ABSOLUTE VALUE OF FACTORS (SIG 4.9%)

In contrast, factor D (three howitzer to two howitzer split basis) is found to be significant during the transient phase but not for the steady state.

In addition to attrition (factor B), factors AB, A, D and BC produced a statistically significant impact on unit productivity potential. Each of these has the magnitude of one howitzer crew working for about .4 hours or about 24 minutes. The impact of each of these factors is less than 10 percent of that caused by a 20 percent change in attrition and while statistically significant is not operationally significant. The most probable reason that early productivity is not sensitive to the factors is that the unit is population limited by attrition. We have already attributed this to rich substitutability. This richness permits wide choices in substitution to compensate for all factors except attrition.

4.5 IMPACT OF FACTORS ON CREW ONE-ROUND MISSIONS PER DAY

There are yet penalties in time which remain to be investigated. These are the time penalties due to going from today's organization to five men per subteam and four men per subteam. The method described here for this investigation takes into account the trade-off between the time penalty and the ability to form more increments of howitzer team capability.

The examination begins with some statistics based on ARI's field measurements and computer simulations. It is understood that these times are approximate and may be longer than times found in an ARTEP-ready crew in a USAREUR howitzer battalion. But it is believed that the trends to be surfaced by this analysis will essentially stand up under crew training variations.

Let us begin with the following times:

Mission	Average Time Todays Organization	Percent Increase for Alternatives	
		5-Man Split	4-Man Split
Emplacement (To include boresight)	10' 55"	5.0%	11.0%
Firing One Round Mission	2' 39"[2]	8.6%	12.7%
March Ordering	2' 56"	14.7%	28.6%

[2] This time includes all the tasks required to obtain the projectile, powder and fuze from within the section vehicle. Subsequent rounds of a multiple round mission could be fired in much less time.

Make the following assumptions:

- Four moves per day for survivability and to provide adequate fire support.
- Each move entails thirty minutes of road time regardless of section size.

Then for a 24-hour period:

Time Allocation	10 Man Team	5 Man Team	4 Man Team
Minutes available	1440	1440	1440
- Travel (4 times)	- 120	- 120	- 120
- Emplace (4 times)	- 4X10'55"	- 4X10'55"X1.05	- 4X10'55"X1.11
- March Order (4 times)	- 4X2'56"	- 4X2'56"X1.147	- 4X2'55"X1.286
= Time Available for Fire Missions	1264.6 (21.0767 hrs)	1260.692 (21.0115 hrs)	1256.441 (20.9407 hrs)
Number of Potential One-Round Missions Per Team	$\frac{1264.6}{2\frac{39}{60}}$	$\frac{1260.692}{2\frac{39}{60} \times 1.086}$	$\frac{1256.441}{2\frac{39}{60} \times 1.127}$
=	477.2	438.2	420.1
(X8 for full-up unit one-round missions)	(3817.6)	(3504.8)	(3356.6)

To continue the example, in the above calculations the 5 man team has 21.0115 hours available. If the unit were full-up there would be 8X21.0115 team-hours available or 168.092 team hours. From Subsection 4.5 we found 7.577 team-hours available for the first 1.5 hours and (21.0115 - 1.5) X 8X.986[3] team-hours available for the remainder of the time or 153.9067 team-hours. When added to 7.577 hours this reflects a total productivity of 161.4837 team-hours. When this is compared with a full up unit with the five team organization it has 151.4837/168.092 or .9607 relative team productivity. When this number is multiplied by 3504.8 full-up unit potential one-round missions the base organization is expected to be able to fire 3367 team (or crew) one-round missions.

While it is recognized that this has not been put into a gaming context to compare the effectiveness of these missions, calculations generalized from the above procedures will provide some important insights when factored out. Of course, wherever the A factor was present then the team missions associatea with four man team time constants were used.

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[3] Base case capability from Section 4.4. Unit "produces" at .986 hours per hour after 1.5 hours since it has reached steady state.

Results of all calculations are shown in Tables 4-5 and 4-6 which correspond in format to Tables A-1 and A-2, respectively. Values less than 45.564 team missions per day are not statistically significant.

The sensitivity tends to verify findings discovered elsewhere or asserted intuitively. Going from the howitzer section with two teams of five to the howitzer section with two teams of four and two supernumeraries has about one-sixth the impact of a 20 percent increase in attrition. But the interaction of this factor with attrition (AB $\longrightarrow$ 27.2%) suggests strongly that at some attrition levels battery capability could be improved by converting to howitzer sections with four man teams with the remainder of the current ten man section used to perform support tasks and for substitution. If this is a satisfactory procedure, it needs to be supported by training. This section shows that going from howitzer sections organized with two teams of five to sections organized with two teams of four is an acceptable degraded mode of operations and, hence, the two teams of five organization is quite robust.

TABLE 4-5. CREW ONE-ROUND MISSIONS PER DAY - FACTORS

a/ FACTOR	CREW MSNS PER DAY	PERCENT b/ OF HIGH	FACTOR c/ VALUE	PERCENT d/ OF HIGH
BASE	3367.0	98.4 %	0.00	0.0 %
A	3297.8	96.4 %	132.39	16.6 %
B	2313.5	67.6 %	-797.30	-100.0 %
AB	2740.7	80.1 %	216.65	27.2 %
C	3421.3	100.0 %	60.12	7.5 %
AC	3290.9	96.2 %	-41.85	-5.2 %
BC	2347.8	68.6 %	18.83	2.4 %
ABC	2732.5	79.8 %	-3.02	-0.4 %
D	3318.0	97.0 %	-28.25	-3.5 %
AD	3285.2	96.0 %	13.32	1.7 %
BD	2281.5	66.7 %	-15.54	-1.9 %
ABD	2625.5	76.7 %	9.31	1.2 %
CD	3408.1	99.6 %	-3.73	-0.5 %
ACD	3282.9	95.9 %	9.97	1.3 %
BCD	2405.6	70.3 %	-6.29	-0.8 %
ABCD	2726.9	79.7 %	11.65	1.5 %
E	3325.0	97.2 %	13.90	1.7 %
AE	3291.9	96.2 %	-7.55	-0.9 %
BE	2320.7	67.8 %	14.87	1.9 %
ABE	2679.3	78.3 %	-12.70	-1.6 %
CE	3422.4	100.0 %	11.77	1.5 %
ACE	3302.0	96.5 %	-14.52	-1.8 %
BCE	2597.4	75.9 %	4.28	0.5 %
ABCE	2732.5	79.8 %	-14.09	-1.8 %
DE	3332.0	97.4 %	-6.03	-0.8 %
ADE	3285.4	96.0 %	26.46	3.3 %
BDE	2283.1	66.7 %	-14.03	-1.8 %
ABDE	2729.0	79.7 %	32.84	4.1 %
CDE	3410.7	99.7 %	-33.70	-4.2 %
ACDE	3294.3	96.3 %	11.39	1.4 %
BCDE	2343.4	68.5 %	-26.13	-3.3 %
ABCDE	2718.9	79.4 %	5.28	0.7 %

a A FIVE TO FOUR MEN PER TEAM
  B 10 % TO 30 % ATTRITION
  C 129 TO 139 PSNL STRENGTH
  D 3 HOW TO 2 HOW SPLIT BASIS
  E 64C TO 13B
b PERCENT OF HIGHEST MEASURED PERFORMANCE
c SIGNIFICANT FOR ABSOLUTE VALUE EXCEEDING 45.564
d PERCENT OF HIGHEST ABSOLUTE VALUE OF FACTORS (SIG 5.7%)

TABLE 4-6. CREW ONE-ROUND MISSIONS PER DAY - FACTORS ORDERED BY ABSOLUTE VALUE OF FACTORS

a/ FACTOR	CREW MSNS PER DAY	PERCENT b/ OF HIGH	FACTOR c/ VALUE	PERCENT d/ OF HIGH
BASE	3367.0	98.4 %	0.00	0.0 %
B	2313.5	67.6 %	-797.30	-100.0 %
AB	2740.7	80.1 %	216.65	27.2 %
A	3297.8	96.4 %	132.39	16.6 %
C	3421.3	100.0 %	60.12	7.5 %
AC	3290.9	96.2 %	-41.85	-5.2 %
CDE	3410.7	99.7 %	-33.70	-4.2 %
ABDE	2729.0	79.7 %	32.84	4.1 %
D	3318.0	97.0 %	-28.25	-3.5 %
ADE	3285.4	96.0 %	26.46	3.3 %
BCDE	2343.4	68.5 %	-26.18	-3.3 %
BC	2347.8	68.6 %	18.83	2.4 %
BD	2281.5	66.7 %	-15.54	-1.9 %
BE	2320.7	67.8 %	14.87	1.9 %
ACE	3302.0	96.5 %	-14.52	-1.8 %
ABCE	2732.5	79.8 %	-14.09	-1.8 %
BDE	2283.1	66.7 %	-14.03	-1.8 %
E	3325.0	97.2 %	13.90	1.7 %
AD	3285.2	96.0 %	13.32	1.7 %
ABE	2679.3	78.3 %	-12.70	-1.6 %
CE	3422.4	100.0 %	11.77	1.5 %
ABCD	2726.9	79.7 %	11.65	1.5 %
ACDE	3294.3	96.3 %	11.39	1.4 %
ACD	3282.9	95.9 %	9.97	1.3 %
ABD	2625.5	76.7 %	9.31	1.2 %
AE	3291.9	96.2 %	-7.55	-0.9 %
BCD	2405.6	70.3 %	-6.29	-0.8 %
DE	3332.0	97.4 %	-6.03	-0.8 %
ABCDE	2718.9	79.4 %	5.28	0.7 %
BCE	2597.4	75.9 %	4.28	0.5 %
CD	3408.1	99.6 %	-3.73	-0.5 %
ABC	2732.5	79.8 %	-3.02	-0.4 %

a A FIVE TO FOUR MEN PER TEAM
  B 10 % TO 30 % ATTRITION
  C 129 TO 139 PSNL STRENGTH
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d PERCENT OF HIGHEST ABSOLUTE VALUE OF FACTORS (SIG 5.7%)

SECTION V

FINDINGS

SECTION V
FINDINGS

This research effort supports the following findings:

- Today's ten member howitzer section, trained in accordance with duties as defined currently, is incapable of providing continuous 24 hour per day fire support in a rapidly moving, high intensity, combat situation, and, at the same time, performing the support and risk reduction tasks required for survival.

- The following alternative howitzer section organizations, with crew duties redefined appropriately, have a reconstitution capability following degradation at least as good as today's organization; are able to provide fire support, at minor cost in response times; and, at the same time, are able to perform required support tasks by alternating the two crews between war fighting and support functions. They are presented in order of preference.

    - Chief of Section and two teams of five crewmen (requires an increase in battery strength from 129 to 137 personnel).

    - Two teams of five crewmen with the Chief of Section a member of one of the teams.

- At an increased cost in response time, it is also feasible, and, in cases of high attrition, it may be salutary, to redefine duties and organize the howitzer section into two teams of four crewmen. This solution is only viable, however, if the howitzer section strength is retained at ten, with the members not essential to team operations used to perform support tasks and to substitute for crew casualties or other crew degradations.

- Crew duties should be developed for a five member team and crew training should be conducted accordingly. Crew duties and crew training should also be developed at the four member team level in the event combat casualties or other degradations reduce howitzer section strength to that level.

- The 129 member howitzer battery organization with howitzer sections organized either in two teams of five or two teams of four members is effectively organized in that:

  - Maximum required personnel demands approximate initial manning.
  - Demands for personnel are essentially equal to capability level.
  - The unit is population limited and not skill limited.

- Of the factors evaluated in the sensitivity analysis, only attrition level, howitzer section organization (five versus four member teams), and the combination of the two factors had operational significance in terms of battery capability level after reconstitution and crew missions per day. Only the attrition factor is operationally significant in terms of team hours available during the reconstitution process.

- Other factors examined, including battery strength (129 vs 139 personnel), three gun platoon versus two gun platoon operations, and skill 63C versus 13B as ammunition section drivers, were not operationally significant in the analyses performed.

SECTION VI

OBSERVATIONS

SECTION VI
OBSERVATIONS

The US Army Research Institute program of field measurement of task time data and their use of the Crew Performance Model to simulate the performance of crews of various sizes with crew duties reassigned appropriately has provided valuable insights into howitzer section effectiveness and efficiency. The research program should be continued to validate the modeling approach and expand the applicability of the ARI model to other weapon systems.

APPENDIX A

THE FACTORIAL SENSITIVITY METHOD — AN EXAMPLE

APPENDIX A

THE FACTORIAL SENSITIVITY METHOD — AN EXAMPLE

Suppose that an automobile trip is taken on two separate occasions. For the first, the average speed is 45 miles per hour. Average speed for the second is 55 miles per hour. Assume that 15 gallons of gasoline were consumed on the first trip and 17 gallons on the second. Then if distance traveled remained constant a conclusion that the increased speed cost two gallons could be drawn.

A more thorough investigation might have revealed that the weight carried changed from the first to the second trip. Tire pressure and wind speed drag could also influence gasoline consumption.

Suppose that there are four factors which are to be tested for their influence on gasoline consumption.

Factor Label	Meaning
A	Speed - from 45 to 55 miles per hour
B	Extra weight - from 400 to 600 pounds
C	Tire pressure - from 22 to 28 psia
D	Wind speed - from 10 to 20 miles per hour

The above table means that whenever the factor is present the meaning is taken at the second (in this case, higher) level. If all factors are absent, it is assumed that the trip is taken at a speed of 45 miles per hour, with a weight load at 400 pounds, a tire pressure of 22 psia and against a frontal wind of 10 miles per hour.

Conceivably each factor could be varied independently of the other factors. This would generate the following 16 combinations of cases.

Case	Speed	Extra Weight	Tire Pressure	Wind Speed	Gas Consumption
Base	45	400	22	10	15
A	55	400	22	10	17
B	45	600	22	10	16
AB	55	600	22	10	19
C	45	400	28	10	14
AC	55	400	28	10	16
BC	45	600	28	10	15
ABC	55	600	28	10	18
D	45	400	22	20	17
AD	55	400	22	20	19
BD	45	600	22	20	18
ABD	55	600	22	20	21
CD	45	400	28	20	16
ACD	55	400	28	20	18
BCD	45	600	28	20	17
ABCD	55	600	28	20	20

It is assumed that where a given factor is at one of its levels, it remains fixed throughout the trial. Moreover, all other factors than those shown above are assumed to remain constant. In the investigation of team organizational requirements, care was taken to assure these conditions.

In the above 16 cases there are eight pairs of speed changes as follows:

Case	Speed	Gas Consumption	Difference in Gas Consumption Due To Speed Change
Base	45	15	
A	55	17	2
B	45	16	
AB	55	19	3
C	45	14	
AC	55	16	2
BC	45	15	
ABC	55	18	3
D	45	17	
AD	55	19	2
BD	45	18	
ABD	55	21	3
CD	45	16	
ACD	55	18	2
BCD	45	17	
ABCD	55	20	3
AVERAGE		$\frac{20}{8}$ =	2.5

The average (also called the factor value) is based on eight comparisons and can be accepted with more confidence than the earlier estimate of 2 gallons based on one comparison.

The Yates' method uses a structure which results in quick analysis estimates of main effects similar to the above. Additionally, interaction values can be calculated.

This chapter will display the results in two formats. The first preserves the same factor order as that portrayed in the foregoing tables and is illustrated in Table A-1.

The second format (Table A-2) results from reordering the rows after the base case row to reflect decreasing absolute factor values. A line is drawn separating those factor values which are statistically significant from those which are not.

The first column of each table contains the factor and factor combination labels (e.g., ABD). Footnote "a" describes each of the factors used. When the factor is present, the physical fact it represents has changed as described in footnote "a." Thus ABD represents a speed of 55 MPH, weight of 600 pounds, tire pressure of 22 psia and a wind speed of 20 MPH. When the factors had these values the gasoline consumption was measured to be 21 gallons as shown in the second column.

TABLE A-1. GASOLINE CONSUMPTION - GALLONS (SAMPLE) - FACTORS

a/ FACTOR	GALLONS CONSUMED	PERCENT b/ OF HIGH	FACTOR c/ VALUE	PERCENT d/ OF HIGH
BASE	15	71.4 %	0.00	0.0 %
A	17	81.0 %	2.50	100.0 %
B	16	76.2 %	1.50	60.0 %
AB	19	90.5 %	0.50	20.0 %
C	14	66.7 %	-1.00	-40.0 %
AC	16	76.2 %	0.00	0.0 %
BC	15	71.4 %	0.00	0.0 %
ABC	18	85.7 %	0.00	0.0 %
D	17	81.0 %	2.00	80.0 %
AD	19	90.5 %	0.00	0.0 %
BD	18	85.7 %	0.00	0.0 %
ABD	21	100.0 %	0.00	0.0 %
CD	16	76.2 %	0.00	0.0 %
ACD	18	85.7 %	0.00	0.0 %
BCD	17	81.0 %	0.00	0.0 %
ABCD	20	95.2 %	0.00	0.0 %

a A SPEED - 45 TO 55 MPH
B EXTRA WEIGHT - 400 TO 600 POUNDS
C TIRE PRESSURE - 22 TO 28 PSIA
D WIND SPEED - 10 TO 20 MPH
b PERCENT OF HIGHEST MEASURED PERFORMANCE
c SIGNIFICANT FOR ABSOLUTE VALUE EXCEEDING 0.000
d PERCENT OF HIGHEST ABSOLUTE VALUE OF FACTORS (SIG 0.0%)

TABLE A-2. GASOLINE CONSUMPTION - GALLONS (SAMPLE) - FACTORS ORDERED BY ABSOLUTE VALUE OF FACTORS

a/ FACTOR	GALLONS CONSUMED	PERCENT b/ OF HIGH	FACTOR c/ VALUE	PERCENT d/ OF HIGH
BASE	15	71.4 %	0.00	0.0 %
A	17	81.0 %	2.50	100.0 %
D	17	81.0 %	2.00	80.0 %
B	16	76.2 %	1.50	60.0 %
C	14	66.7 %	-1.00	-40.0 %
AB	19	90.5 %	0.50	20.0 %
BC	15	71.4 %	0.00	0.0 %
ABC	18	85.7 %	0.00	0.0 %
AC	16	76.2 %	0.00	0.0 %
AD	19	90.5 %	0.00	0.0 %
BD	18	85.7 %	0.00	0.0 %
ABD	21	100.0 %	0.00	0.0 %
CD	16	76.2 %	0.00	0.0 %
ACD	18	85.7 %	0.00	0.0 %
BCD	17	81.0 %	0.00	0.0 %
ABCD	20	95.2 %	0.00	0.0 %

a A SPEED - 45 TO 55 MPH
B EXTRA WEIGHT - 400 TO 600 POUNDS
C TIRE PRESSURE - 22 TO 28 PSIA
D WIND SPEED - 10 TO 20 MPH

b PERCENT OF HIGHEST MEASURED PERFORMANCE

c SIGNIFICANT FOR ABSOLUTE VALUE EXCEEDING 0.000

d PERCENT OF HIGHEST ABSOLUTE VALUE OF FACTORS (SIG 0.0%)

The third column ("PERCENT OF HIGH") relates the corresponding value in the second column to the highest value in that column in terms of percentage. This provides, at a glance, the relative values of the performance measured.

The fourth column ("FACTOR VALUE") displays the calculated factored-out results. As an example, the factor value associated with factor A is 2.50.[1] This means that "on the average" factor A (45 to 55 MPH) increases gasoline consumption by 2.5 gallons (as was found earlier by averaging eight comparisons). Footnote "c" identifies the statistically significant threshold. When the format is that of Table 4-1, the factor value can be compared with any other factor value of interest. When the format is that of Table 4-2, the factor value is used to locate a line separating significant from non-significant results.

The fifth and last column presents relative values. The highest absolute value of the Factor Values (fourth column) is considered 100 percent. All others are related to that value. Footnote "d" displays a significance percentage corresponding to the significance threshold in footnote "c."

Table A-2 can now be interpreted. The speed variations shown (factor A) contributed to the largest increase in gas consumption followed by wind speed (factor D) and extra weight (factor B), in that order. Raising the tire pressure (factor C) had a salutary effect on consumption. Whenever both speed and weight are increased, the consumption change is more than the change associated with the individual effects; i.e., there is a synergism between factors A and B as reflected by the AB line.

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[1] For lines with two or more factors, the "factor value" estimates only the interaction shown and not a cumulative effect of all factors in the combination.